

June 2004

MEETING REPORT

21st International Battery Seminar And Exhibit
Ft. Lauderdale, FL USA
March 8 - 11, 2004
By Lawrence A. Tinker, Ph.D.

Around The Industry

Product News

Patents

Previous Issue

ABT ARCHIVE

EXCLUSIVES

MEETING REPORT

BATTCON 2012 International Stationary Battery Conference
Hollywood, CA
USA

MEETING REPORT

BCI 124th Convention & Power Mart Trade Fair
Scottsdale, AZ
USA

MEETING REPORT

29th Florida Battery Seminar Part 2
Ft. Lauderdale, FL
USA

PHOTO REPORT

29th Florida Battery Seminar Part 1
Ft. Lauderdale, FL
USA

JUNE 2004

Advanced search



A new post for Enersys's GU/GT line of flooded batteries, cross-drilled for easy installation of batteries in any direction, also makes it possible to maintain cells online. > story

AROUND THE INDUSTRY

Saft Receives NASA Praise as Member of MER Team

In the case of the recent success of the Mars Exploration Rover (MER) program, NASA is quick to cite the contributions of about 25 companies – mostly small or medium-sized operations – that were at the heart of the space triumph. "These companies deserve our undying thanks; they really did it right," says Peter Theisinger, outgoing MER project manager.

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NASA's Jet Propulsion Laboratory led the \$800 million effort. Theisinger realized early on that the smaller companies far outnumbered the larger firms. "If these people do not do their jobs right, we all will fail," he said.

As history tells us, they did their jobs right. Saft America provided the powerful lithium sulfur dioxide batteries which powered both the Spirit and Opportunity Rovers during the critical entry, descent, and landing phases of the mission. They join other companies that met the challenge with air bags, parachutes, descent rockets, electric motors, and other smaller components that combined for mission success.

Both Spirit and Opportunity had five Saft batteries each composed of 12 D-size cells. The company spent almost two years in design/development at its research and development center in Cockeysville, Maryland, and delivered the first lithium sulfur dioxide batteries to NASA in December 2002.

Ener1 Forms Nanotechnology Subsidiary

Ener1 Inc. of Ft. Lauderdale, Florida, has formed a new wholly owned subsidiary, NanoEner Inc., to develop new markets and applications for its proprietary technologies to manufacture nanomaterials. Dr. Yevgen Kalynushkin, an engineer, professor of material science, and author of more than 12 patents and 300 published papers, is chief technology officer of the new company.

Kevin Fitzgerald, chairman and CEO of Ener1, said that forming NanoEner will help Ener1 capitalize on the emerging nanotechnology market, estimated by the National Science Foundation to reach \$1 trillion by 2015.

Ener1 currently uses its nanomaterials manufacturing technologies to develop nanomaterials for lithium batteries and other high-energy storage devices. Its nanostructured electrodes enable batteries to have high discharge rates and extended cycle life. This patent-pending process is based on a vapor deposition solidification method invented by Dr. Kalynushkin that uses thin-film technology to fabricate high-quality, inorganic nanostructures. The process can be applied to a wide range of structures, from raw materials and nanopowders to ultra-thin film coatings for displays and wires.

N-Charge Found at Best Buys in U.S. Military

Best Buy Co., Inc. has ordered Valence Technology's second generation N-Charge™ Power Systems.

"We have seen the need for a universal notebook battery grow over the past year, and the new N-Charge system will enable us to serve more customers," says Scott Bachinski, business team leader of the nationwide chain. "Our partnership with Valence has been successful to date, and we look forward to

continuing the relationship.”

The U.S. military also has chosen the N-Charge Power System for many of its devices, the most recent being survey equipment for its Special Operations Command.

Medis, Kensington Announce Strategic Partnership

Medis Technologies Ltd. and Kensington Technology Group, a division of ACCO Brands, Inc., have announced a strategic partnership to distribute and market new products using Medis's proprietary fuel cell technology, including the Medis Power Pack, which provides extended power to cell phones, digital cameras, MP3s, handheld gaming devices, PDAs and other portable electronic devices.

Kensington and ACCO have distribution relationships with thousands of stores that sell Kensington's computer accessories, as well as ACCO office product brands, including Swingline and Day-Timer. As part of the limited, exclusive agreement, Kensington will market and distribute Medis fuel cell technology worldwide under the Kensington brand name.

Medis plans to equip Kensington's sales organizations with power packs by the end of this year, enabling them to start demonstrating the product to customers quickly.

For details, visit www.medistechnologies.com.

Cleaner Diesel-Electric Hybrid Bus Planned By TTC

The Toronto Star reports that in two years hybrid buses should be on the streets in Toronto.

Rick Ducharme, chief general manager of the TTC, is planning to feature diesel-electric engines on all 330 buses which the TTC will order this summer. They use up to 33% less fuel and cut carbon monoxide emissions up to 90%. "Hybrid is the future," Ducharme says.

At the moment there are only two dozen hybrid buses on North American streets, although this should change soon. Seattle has ordered 235 of GM's hybrid buses while New York City has ordered 325 buses from GM's main competitor, BAE. It takes up to two years to fill an order.

A diesel-engine bus costs \$500,000 and a bus powered by GM's hybrid engine costs \$760,000. Transit systems could make up the cost due to cheaper fuel prices and less service time on engines and brakes.

Argonne Developing Space Battery

Argonne National Laboratory-West in Idaho is developing a radioisotope thermoelectric generator, or space battery, that can survive in a space environment for decades, reports the Pocatello Idaho State Journal.

The space battery may help NASA discover if water exists on Jupiter's moons. It will be attached to a long-range exploration probe and should be launched by 2012. It will power the probe and protect its instruments from freezing in space.

Ultralife Receives \$1.5 Million Order

Ultralife Batteries, Inc., of Newark, New York, has received a \$1.5 million order to supply custom lithium-ion batteries and chargers to Cubic Defense Applications, the defense segment of Cubic Corp. The order is for production quantities of custom lithium-ion rechargeable batteries and chargers for Cubic's Weapons Effects Simulation land-based combat training system for the Canadian Armed Forces. Battery and charger deliveries are scheduled to continue through October 2005.

John D. Kavazanjian, Ultralife's president and chief executive officer, says, "This order further reinforces Ultralife's leadership role as a supplier of advanced lithium and lithium-ion batteries and chargers for use in critical military systems."

Powered by Ultralife's 14V, 6Ah lithium-ion batteries and multiple-bay chargers, the simulation system includes Cubic's new Precision Combat Training System and advanced software-based exercise control and after-action review technology.

Contact Peter Comerford, Ultralife Batteries, Inc., (315) 332-7100, pcomerford@ulbi.com.

Exide Industries to Enter U.S. Auto Market

Exide Industries of New Delhi, India, is designing batteries suitable for the American automobile market.

"U.S. automobile market is so huge that we are looking at only 1 to 2% of their market. They have a different design and we have the equipments to make batteries for them," says Exide Chairman S. B. Ganguly.

Ganguly, however, expressed concern over the import duty on lead, a main input for battery manufacturing. Import duty has been kept at 20% for both finished batteries and lead. This would encourage imports due to duty advantage in other countries, especially China and other East Asian countries.

Lead comprises 70% of the total material cost and an immediate correction in this anomaly would hit the domestic manufacturers badly.

Speaking for the Indian Battery Manufacturers Association (IBMA), Ganguly asked the government for an immediate reduction in duty on lead to 5%.

Hitachi and Shin-Kobe Consider Joint Venture

Hitachi, Ltd. and Shin-Kobe Electric Machinery Co., Ltd. are considering a joint venture company to market, develop, and manufacture rechargeable lithium-ion batteries for hybrid electric vehicles. The new company would be established in fiscal 2004.

In 2000, Hitachi and Shin-Kobe led the world in commercializing products for HEV, and in 2003 mass produced a rechargeable lithium-ion battery for electric scooters. Hitachi offers a complete HEV system lineup, including rechargeable lithium-ion batteries.

Plans call for the proposed joint venture to build a pilot line this fall.

Visit www.shinkobe-denki.co.jp.

EaglePicher Gets Li/MnO₂ Contract with CECOM

EaglePicher Energy Products Corp. (EPEPC) has received a five-year, multi-million dollar contract to supply its Next Gen II, Phase III, Large Cell, Lithium Manganese Dioxide (Li/MnO₂) batteries to the United States Army Communications-Electronics Command (CECOM).

EPEPC, a manufacturer of lithium sulfur dioxide (LiSO₂) batteries, currently supplies CECOM with the Li/SO₂ version of these batteries under its existing Next Gen II, Phase I, LiSO₂ contract. EPEPC has supplied Li/MnO₂ batteries to CECOM in the past and has submitted its proposal to deliver the Next Gen II, Phase IV, Li/MnO₂ Rectangular Battery Group.

The batteries, manufactured in Vancouver, Canada, have a higher energy density than present Li/SO₂. The Li/MnO₂ will be used by the U.S. Army in its fielded communications equipment. Deliveries are set to begin in 2005.

For more information, visit www.eaglepicher.com.

Europe to Halve Battery Waste

Members of the European Parliament (MEPs) called on Europeans to recycle half the batteries they use.

Parliament voted to up the recycling rate to a standard 50% across the EU, rather than the original suggestion of 160g per inhabitant per year.

A green amendment to phase out the use of cadmium batteries was also agreed on, despite strong objections from conservative MEPs.

British conservative MEP Robert Goodwill is disappointed the amendment was passed, given that it was based on a political campaign and not scientific evidence. The result was very close, with 283 in favor and 225 against.

The U.K. has one of the worst records for battery recycling in Europe. In 2002, Belgium managed to collect 250g of batteries per inhabitant, the U.K. only 2g.

Wilson Greatbatch COO Resigns

Jose E. Almeida has resigned his position as executive vice president and chief operating officer at Wilson Greatbatch Technologies, Inc., to accept an executive position with his previous employer, Tyco Healthcare.

Edward F. Voboril, WGT's chairman, president, and chief executive officer, said, "While I am sorry to see Joe leave, I am grateful to him for his many significant contributions and I wish him success in his future endeavors."

On an interim basis, the operational leadership team that reported to Mr. Almeida will report directly to Mr. Voboril. WGT, a leader in implantable medical devices, is exploring organizational alternatives.

Arotech Subsidiary Gets MAV Contract

Arotech Corporation's Electric Fuel subsidiary has received a follow-on contract from an Israeli security agency to continue developing prototype zinc-air cells for Micro Aerial Vehicles (MAVs) that can maintain flight for extended periods of time.

In June last year, a zinc-air battery developed under the previous contract powered a MAV in a flight longer than that achieved with the same MAV using a high-performance lithium-ion polymer battery.

"MAVs and other unmanned ground and airborne vehicles need advanced power sources," said Robert S. Ehrlich, Arotech CEO. "Our zinc-air battery can significantly increase mission time for these vehicles."

Visit www.arotech.com.

American Automotive Suppliers Honored by French

Johnson Controls Inc., based in Milwaukee, Wisconsin, Cignet LLC in Troy, Michigan, and AxleTech International, also in Troy, were honored by the French government at the ninth annual Invest in France Automotive Awards ceremony

held at the Detroit Institute of Arts during the 2004 SAE World Congress.

The Invest in France Automotive Awards are presented annually to recognize leading North American automotive companies that have made a significant investment in new or expanded facilities in France.

With 19 vehicle manufacturing plants producing over 3.6 million vehicles annually, the country is Europe's second largest automotive manufacturing center. Paris is the leading automotive purchasing center for the continent, with purchasing decisions there affecting nearly 14% of global vehicle production.

Each of the three companies received a limited-edition crystal automobile designed and cast by the world-renowned glasswork manufacturer Compagnie Française du Cristal Daum. Receiving the awards on behalf of their companies were Keith Wandell, president, automotive group of Johnson Controls, Inc.; Richard Crawford, chairman of Cignet LLC; and Mary Petrovich, CEO of AxleTech International.

Pellegrino Resigns from Rayovac Board

Philip F. Pellegrino has resigned from Rayovac Corp.'s board of directors and has entered into a consulting agreement with the company to provide advice and leadership in the areas of global sales, customer relationships, and business integration.

Pellegrino has been a director of Rayovac since November 2000, serving both the audit and compensation committees. He recently announced his retirement from a 40-year career at Kraft Foods, where he served as senior vice president and president of sales.

The company is in an active search to fill Pellegrino's board seat.

Tyco and Midtronics Join on Monitoring System

Tyco Electronics Power Systems Inc. and Midtronics Inc. have an agreement that includes licensing Midtronics' patented battery conductance monitoring technology and developing a telecom battery monitoring to ensure network integrity. The system will be integrated into Tyco's GALAXY power monitoring system.

Users will be able to view conductance values on-demand or in user-defined intervals via Internet, a cost-effective solution for customers in new and retrofit applications. Because it uses the existing GALAXY DC Power System internal communication bus, the need for a stand-alone hardware platform to collect and process conductance from multiple battery strings is eliminated.

Midtronics Files Suit Against DHC

Midtronics Inc. of Long Beach, California, has filed a patent infringement lawsuit against DHC Specialty Corp. of Taipei, Taiwan, in Federal District Court in Chicago. The suit claims that DHC products violate patents assigned exclusively to Midtronics in the area of battery testing technology.

Steve McShane, Midtronics CEO, says, "For the past 20 years, Midtronics has focused entirely on battery management innovation, investing significantly in research, engineering and product development. This lawsuit confirms that our commitment to innovation is reinforced by our resolve to defend our intellectual property."

Lithium Technology Elects Kruger as CEO

Lithium Technology Corp. has elected its president and chief operating officer, Franz Kruger, as its new chief executive officer, succeeding David Cade. Cade will remain as chairman of the board in a full-time capacity.

"The company and our shareholders are very fortunate to have a CEO with Franz Kruger's international battery industry credentials and stature," Cade says. "His global reputation in the advanced battery arena encompasses technology, production, distribution, sales and marketing."

Crane Announces New Website

Crane Nonwovens has a new website that provides information on the company, facilities, and the variety of interwovens Crane produces. The site also lists trade shows and events where Crane will be exhibiting. In addition, visitors can request information and product samples.

"The new website is a valuable source of information for design engineers, fabricators, and others seeking materials that meet the most critical performance specifications for present applications or future generation products," says Matthew J. Miller, manager of marketing and business development.

Visit www.cranenonwovens.com.

Rayovac Announces Management Change

Stephen P. Shanesy, executive vice president, strategic initiatives, has resigned from Rayovac Corp. After joining Rayovac in 1996 as senior vice president of marketing and general manager of general batteries, Shanesy went on to serve in a variety of roles, including executive vice president - North America, before assuming his current role in January 2004.

"In the eight years that Steve has been part of the Rayovac organization, the company has doubled in size and grown to be a global player in the consumer

products industry. We appreciate his many contributions," says David Jones, Rayovac chairman and CEO.

VRB Power Signs Development Pact with Magnetek

VRB Power Systems Inc. of Vancouver, Canada, has signed a memorandum of understanding with Magnetek Inc. of Chatsworth, California, to jointly develop a battery replacement product using the Vanadium Redox Battery Energy Storage System (VRB-ESS) technology.

VRB will provide Magnetek with the base technology, and Magnetek will provide the product design, integration, and channels to market for the telecommunications industry. VRB and Magnetek will offer an alternative to traditional lead-acid battery technology with a reliable and environmentally safe energy storage product for switching centers and wireless base stations.

Valence System to Be Evaluated by Graham-Field

ValenceTechnology, Inc.'s U-Charge™ Power System will be evaluated by Graham-Field Healthcare Products, a major manufacturer and distributor of healthcare products, for use in power wheelchair products.

The U-Charge Power System is a direct replacement for the sealed systems currently available in the power mobility market, delivering greater energy density and better reliability at a lower cost of ownership than lead acid batteries. The inherent safety of Saphion technology enables large format products and eliminates safety and environmental concerns associated with other technologies.

"We have been waiting a long time for a lithium-ion technology that was safe enough to be manufactured in unique dimensions for our industry," says Joe Ticer, director of mobility and rehab at Graham-Field.

BYD Plans Leading Role in Auto Industry

BYD Co. Ltd., the world's second largest maker of rechargeable batteries for mobile phones and a newcomer in the auto sector, plans to become one of China's major car manufacturers in 10 years, reports The China Daily.

This private firm took a majority stake in Xi'an Quinchuan Auto Co., the only state-approved car producer in northwestern China, in January 2003.

BYD also co-operated with several world-renowned companies, such as Motorola, Delphi and Autoliv, to form an international research and development team in Shanghai for the new company. It sold more than 20,000 Flyer mini family cars last year and has designed four models. The 1.6-liter BYD316 will be the first car with the BYD brand. The firm's future products will

be sedans and electric cars, not mini cars, says Wang Chuanfu, chairman.

Lockheed Martin Awards Solar Cells Contract

Lockheed Martin has awarded a contract to Uni-Solar Ovonic of Auburn Hills, Michigan, to develop and deliver solar cells on polymer substrates. These cells will be used in Phase 2 of the High Altitude Airship (HAA) program of the Missile Defense Agency.

Uni-Solar Ovonic is working with aerospace companies to develop space and stratospheric photovoltaic products under contracts from the U.S. Air Force Research Laboratory. The flexible, low-cost products can be bonded to a curved skin or stowed for deployment in satellites.

“The high-altitude airship prototype will demonstrate the technical feasibility and utility of a regenerative, solar-powered airship,” said Mike Baumgartner, Lockheed Martin’s HAA program director.

Lockheed Martin was awarded a contract for Phase 2, design and risk reduction activities, in September 2003. Phase 2 includes developing an airship that can sustain operations for one month at 65,000 feet while providing 10kW of power to a 4,000 pound payload. The prototype will become part of the Ballistic Missile Defense System Test Bed following the successful demonstration in 2006.

Visit www.uni-solar.com.

PRODUCT NEWS

Energys’s GU/GT Flooded Batteries

EnergSys has a new post for its GU/GT line of flooded batteries, used for long duration float applications such as central office and mobile switching office standby power.

The post (shown on page 1) is cross-drilled to allow for easy installation of battery cells in any direction. It has been redesigned from oblong to square to increase the contact surface area, allowing the post to be drilled in both directions with the plates either parallel to the rack support rails to optimize battery system footprint or perpendicular to the rails for easier element inspection.

The design enables cell maintenance without taking the entire battery system offline, due to the ability to use four intercell connectors regardless of cell orientation with the new GU/GT post. Two connectors can be left in operation while the other two connectors are being cleaned.

The GU battery starts at \$1,602.

Visit www.enersysreservepower.com/catalog.asp or
www.enersysreservepower.com/sales.asp.

China Chemical Industry Yearbook 2003

Business Data International Inc. has published an English-language China Chemical Industry Yearbook 2003. The yearbook includes sections such as general status of the development of China's chemical industry; policies and administration; science and technology; investment and construction; development of major trades; import and export business of chemicals; capital market of the chemical industry; profiles of enterprise and statistical data.

The 340-page yearbook is \$199.50 plus 10% for airmail postage from: Business Data International Inc., P. O. Box 28547, Verdun Ave., Montreal, QC H4G 3L7, Canada. Fax: (514) 221-3281, email: info@businessdataint.com,
www.businessdataint.com

Yuasa 2004 Applications Catalog

Yuasa Battery Inc. has introduced both published and online versions of its new 33-page applications catalog for 2004, according to Darrell Wilson, vice president of sales and marketing at the Reading, Pennsylvania, company.

The catalog includes a "Yuasa Information and News Section" that details Yuasa's "Ask Y" advertising campaign and new packaging for 2004. It also includes sections entitled, "Features and Benefits" and "Top-Selling Batteries and High Performance Upgrade Options."

To receive a free copy of the new catalog, call (610) 929-5781, ext. 118, or visit www.yuasabatteries.com.

The Nickel and Cobalt Briefing

A report by GFMS Metals Consulting says nickel and cobalt have led the bull market in the last year with prices rising by 250% and 350%, respectively, from recent lows. The report considers the "bull market" argument and gives a detailed assessment of the prospects for both nickel and cobalt out to 2010.

The report has a unique structure which allows both considerable savings and the ability to keep track of the ever-changing conditions in the nickel and cobalt markets. Readers will be able to subscribe to sections on the individual metals, or will receive a substantial discount if they subscribe to the report on both nickel and cobalt, and will receive a concise update of the report after 12 months to take into account changes in the economic cycle and supply projects under consideration.

For information, email: sales@metal-pages.com.

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from June 2004 ABT

MEETING REPORT

21st International Battery Seminar and Exhibit

Ft. Lauderdale, FL USA

March 8 - 11, 2004

by **Lawrence A. Tinker, Ph.D.**

Battery Industry Consultant

Atlanta, GA USA

The 21st Annual Battery Seminar and Exhibition opened in the Ft. Lauderdale Convention Center on March 8 with an introduction by **Shep Wolsky** and **Harry Taylor**. There were several areas of focus at the seminar, including future power requirements for portable devices, lithium-ion battery safety and new developments, advances in alkaline batteries, and fuel cell developments.

In his opening remarks Taylor commented on the scope of the topics with the following questions to the audience: "Can we make a consumer-safe lithium-ion cell?" "Is lithium-ion at its flattening point in terms of capacity capability?" "How can fuel cells, fuel cartridges, and batteries interact to provide solutions to future needs?" All of these were presented as challenges for focusing the direction of new development in the industry.

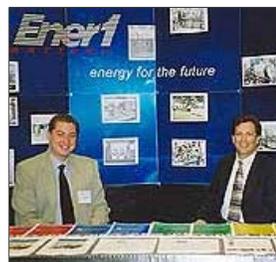
The initial papers addressed the market needs for portable power. **Kamal Shah** of Intel opened the conference proceedings with a presentation on the need for longer battery life. Shah reported on the status of the Mobile PC Extended Battery Life Working Group (EBL WG) formed in late 2002. The group consists of more than 20 companies working to develop guidelines for the mobile PC industry. Currently there is a wireless growth explosion in the mobile PC area. Projections are that wireless will grow at a compound annual rate of >40% through 2008, there will be over 190,000 "hot spots" by 2007, and 89% of mobile computers will be wireless by 2005. All of this is putting additional pressure on the need for longer lasting and higher energy batteries. The key message was that industry-wide collaboration and demonstrated power source innovation are re-quired to address this issue.

Peter Gaucher of IBM discussed the concept of "Pervasive Computing" and how it is driving the growth of mobile devices and globalization of technology. Devices are becoming platforms rather than stand-alones and need to be able to communicate/integrate across a wide variety of applications. The ability to respond in a rapidly changing environment and the need for information that "follows you around" are both driving an explosion in mobile devices. The implications for portable power are the need to develop customized systems that interact with usage patterns and can provide an "invisible" power source to the consumer.

Jason Howard of Motorola reported on the efforts of the IEEE P1625 Working Group to develop system level standards for rechargeable batteries for portable computing. This standard would establish criteria for design analysis for lithium-ion and lithium-ion polymer battery qualification, quality and reliability. It also would provide industry with documented guidance for design of batteries for portable computing, is voluntary, applies to the entire system and not just the battery, and places emphasis on design analysis to incorporate prior knowledge and experiences from industry. The working group consists of more than 15 companies with more than 50 participants. A final draft of the standard has been sent to the IEEE Standards Review Committee for approval.



Enjoying a coffee break with Superior Graphite's Gerry Hand and Igor Barsukov are Rachid Yazami of Cal Tech (left) and Heike Gabrisch of the University of New Orleans.



Ready to explain Ener1's proprietary battery nanotechnology and fuel cell control system are Tim Pastushkin and John Hackenberg.



They come from Alabama, not with banjoes but with calenders, coaters, and slitters: the father-son team of Dan and Don Nielsen.



Manning Arcotronics's booth at the Florida battery show are Ken Rudisuela and Pier Bernini.



Showing Richard Dunne of Motorola what Digatron Firing Circuits' test equipment can do for him is company president Jeff Snell.



A rotating drum of sawdust attracted attention at Littleford Day's booth where Bill Barker and Charlie Kroeger could explain it.

Dr. Jeff Dahn of Dalhousie University opened the discussions on lithium-ion technologies, reporting on his efforts to develop a "drug store" lithium-ion cell, or one that can be used to replace consumer nickel cadmium, nickel metal hydride, and alkaline cells on store shelves. The key issues that need to be addressed in this effort are safety, cost, energy density, performance, and charge control. Safety is the most important and needs to be "bullet-proof." Cost needs to be similar to NiCd and performance and energy density better than NiCd and NiMH. Dahn discussed each of these points and identified potential solutions for most of them. The recommendations included the use of LiFePO₄ and graphite or Li₄Ti₅O₁₂ as the electrodes and LiBOB (lithium bis[oxalate] borate) as the electrolyte salt. The one area that still needs closing in on is the identification of a "shuttle" type mechanism as a means of improving charge control safety to help bring a lithium-ion cell to the consumer market.

Guoying Chen from Lawrence Berkeley Labs presented an interesting technique for improving the safety of lithium-ion cells that utilizes electro-active polymers to prevent overcharge and over-discharge during cycling. The technique involves using polymers that become conductive at certain voltages. An electro-active polymer material is combined with a commercial micro-porous separator to form a composite membrane for use as a separator in the battery. These membranes were evaluated in Li-TiS₂ and Li-Li₂Mn₄O₉ cells. When the voltage of the battery goes above the cutoff voltage of 3.2V, the polymer becomes conducting and shunts the current between the electrodes so that lithium is not overcharged. Development of polymers that could behave similarly at 4V will require further work.

Yazid Saidi of Valence Technologies reported on their efforts to identify alternative cathodes for the lithium-ion system. They have focused on the lithium metal phosphates as the most promising next generation materials for cathodes. These are generally olivine phosphates, and their structure prevents the lithium-ion from moving in a non-linear fashion by confining its movement to one-dimensional tunnels. One example given was Li₃V₂(PO₄)₃, or lithium vanadium phosphate. Test results demonstrating greater than 450 cycles were presented for this cathode material as well as results for lithium cobalt phosphate and lithium iron phosphate.

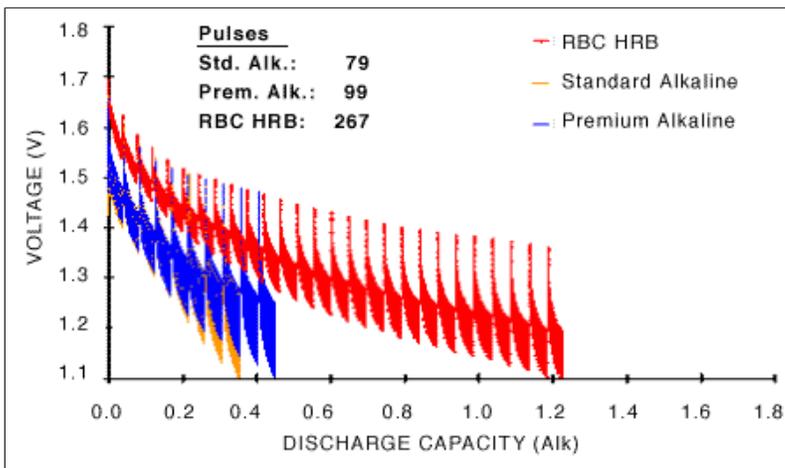
Denis Geoffroy of Phostech Lithium reported on their efforts to develop materials based on LiFePO₄ using carbon-coated phosphate particles to improve the performance and safety of the system. The carbon-coated materials offer higher power capability than pure LiFePO₄. They reported the ability to achieve 60% capacity at 10C rates and up to 60mAh/g at a 40C rate. They are continuing their efforts to optimize the carbon content of the material to maximize performance and have identified high and low power grades for specific applications.

Dr. Brian Barnett of TIAX discussed the general effort to develop alternative cathode chemistries for use in lithium-ion batteries. The goal of these efforts is to improve the stability and safety of lithium-ion cells. There is an increased desire to look at alternatives to LiCoO₂ because of safety reasons and the fact that cobalt prices are going up. Nickel-based materials can provide an alternative; however, safety of these types of materials must be improved. Barnett discussed some of the work at TIAX looking at adding dopants to the LiNiO₂ material to improve its safety. Through chemical and quantum mechanical modeling of the LiNiO₂ they identified that the safety of the system is related to stability of the base structure in the cathode material during cycling. Researchers have focused on looking at ways to add dopants that can stabilize the structure of the cathode material to prevent "collapse" of the Ni-Ni structure and allow lithium ions to continue to move freely in the system. They have achieved improved safety and high rate capability with good cycle life.

Dr. Igor Barsukov of Superior Graphite opened the session on Recent Advances in Battery Technologies and Applications with a discussion of nano-sized graphitic compounds to improve conductivity in power source applications. Superior has partnered with Columbian Chemicals Co. to

develop a new nano-sized material called Pureblack™ Carbons. These are partially graphitized, nano-sized carbons that give improvements over acetylene black and other carbons in power applications. The starting carbon is a high quality furnace black that is then heat treated by Superior. The heat treatment then partially graphitizes the carbon and produces a purer material. Electrochemical testing shows that the Pureblack carbon significantly improves the performance of EMD cathodes over those with synthetic or battery grade carbon black.

Dr. Brendan Coffey discussed developments in high rate cylindrical alkaline technology at RBC Technologies. RBC mainly has been associated with alkaline rechargeable systems; however, this is a primary Zn/MnO₂ system that provides two to three times the energy capability of standard alkaline cells in high rate discharges. Coffey presented data showing that the RBC technology can provide high energy content at high rate and maintain that energy content at low-rate discharge. The technology uses similar materials to those in standard bobbin alkaline cells but differs in internal construction. This allows increased anode-to-cathode interfacial surface area and improves the rate capability of the cell. The most impressive performance improvement is seen in simulated digital camera pulse testing as shown in the graph on page 20, where the RBC technology outperforms both standard and premium alkaline cells by two to three times. RBC is continuing its development of this technology and plans to have pilot line capability in place by the end of 2004. Coffey also reported that RBC is developing a prismatic version of this technology and showed preliminary test results indicating discharge capability of 1.3Ah to 1.0V in a 7/5 F6 size cell at 500mA discharge rate.



Jane Blasi from Duracell introduced two new prismatic designs being offered to consumers, one a "gum pack" primary alkaline cell for audio devices (LP1), shown at left below, and the other a prismatic lithium primary battery (CP1) for digital camera applications. The LP1 cell is a thin prismatic cell and its specifications indicate it can deliver 1460mAh at a 50mA discharge rate. The devices that can use this cell are somewhat limited today but the trends in the market show an increasing demand for this form factor with market projections showing LP1 compatible devices at approximately 20% of new sales by 2008. Duracell is working with device OEMs to further enhance the growth of devices suited for this technology. The CP1 lithium cell delivers 2300mAh at 35mA and is a direct replacement for the NP-60 lithium-ion battery. Currently 33% of cameras that use prismatic cells use the NP-60 battery and this is expected to grow to 39% in 2004.

The battery offers consumers the convenience of being charged when purchased and the ability to carry spare batteries without the need for a charger. Duracell is also working with OEMs to expand the device compatibility for this technology. Blasi reported, too, that Duracell is monitoring the power/energy needs of new and emerging devices and is committed to delivering power sources that suit the needs of OEMs and consumers. Future work at Duracell includes the prismatic format cells, air-managed zinc air, fuel cells and new chemistries.



Stefan Pfrommer from Renata reported on the development of batteries for a new application in tire pressure monitoring systems. These batteries

are used to power RF systems that report tire pressure in vehicles. This is a growing market, mainly due to the U.S. government requirement that all new passenger vehicles have this type of system by 2006. As one can imagine the operating environment is extremely rugged with some of the requirements being 10-year operating life, operating temperature range of —40C to 85C, operating voltage between 1.8 and 2.4V, shock, vibration, and acceleration tolerance. The most likely candidates for this application are LiMnO₂ and LiCFx batteries. Pfrommer reported on the progress Renata has made in developing the LiMnO₂ system and that Renata is already supplying this type battery for TPMS applications.

This year the conference included a session on Small Fuel Cells. This began with an overview of micro-electro mechanical systems (MEMS) technologies presented by **Valluri Rao** of Intel. He presented details on MEMS technology itself, discussed its relevance to micro fuel cells, and provided some examples of possible applications for fuel cells. MEMS are 3-D structures with micron-size lateral dimensions fabricated using IC compatible batch processing techniques. These devices can include mechanical sensing and movement/actuation mechanisms. Today there are still many issues to overcome in producing MEMS devices that are reliable and long lasting, although a significant amount of research is ongoing to overcome these problems. For the micro fuel cell, MEMS technology can help develop miniature pumps and valves that can assist in the operation of the fuel cell. The technology can also be applied to providing micro fluidic channels for fuel flow and micro reactors for reformer processes.

Stephen Voller of Voller Energy, a U.K. company, reported on developments of portable fuel cell systems they have developed for use in recharging batteries in portable devices. These systems take advantage of the combination of a constant output from the fuel cell combined with a rechargeable battery to supply long-running power for portable devices. The battery can supply the instant-on capability for the device while the fuel cell supplies the power for long-run applications. Voller showed photographs of models of the fuel cell charging system they have developed for this purpose.

Dr. Shailesh Shah reported on advancements in hydrogen storage and development of fuel cell technology for portable products at Millenium Cell Inc., a company that licenses enabling technology developments for the hydrogen economy. Their prototype systems utilize sodium borohydride as a system for storing and generating hydrogen for the fuel cell. Shah showed prototype designs for PDA and consumer electronic devices. He also discussed the Hydrogen on Demand™ hydrogen generation technology developed by Millenium Cell.

Jim Kaschmitter of Ultracell reported the development of a new reformed methanol micro fuel cell stack that produces 20W in about 60cm³ of volume. Both the reformer and fuel cell are fabricated on silicon chips. He said the UltraCell FuelChip-based fuel cell yields substantially better performance than DMFCs. Kaschmitter described three applications that they have developed, one for a laptop computer and the other two for separate military products. In the laptop application there is an opportunity to replace a nine-cell lithium-ion battery pack and achieve a 2X performance improvement. For the military application the opportunity lies in the possibility of a 70% reduction in weight.

Dr. Jürgen Pawlik of Celanese Ventures GmbH, reported on developments of membrane electrode assemblies for PEM fuel cells. These MEAs are PBI-based and are marketed under the Celtec® brand name. The membranes are an alternative for Nafion® and provide improved performance in DMFCs. Celanese is continuing development of these membranes to improve their power density.

Dr. Mark Hampden-Smith of Cabot Superior MicroPowders provided an extensive overview of fuel cells that included a discussion on issues and challenges facing this industry. These included performance, packaging, miniaturization, conversion efficiency, reliability, consumer acceptance, and safety. One area of particular focus is catalyst materials and catalyst distribution. CSMP has developed powder production techniques that allow it to customize materials for particular applications. In the fuel cell area they have produced electro-catalysts for DMFC applications that can achieve 35mW/cm² at loading of 4mg/cm². CSMP can custom-engineer particles for the energy, electronics, and display industries, among others.

Dr. Franz Kruger of LTC/GAIA reported on their development of high energy and high power lithium-ion polymer batteries for HEV, military and stationary applications. The HEV battery consists of 80 6Ah cylindrical cells and has specific power of 1500W/kg and power density of 3750W/l. Their military battery is based on the BB-2590 form factor and uses fast-charge D cells. The stationary battery example was a 48V/60Ah battery for traction or backup communications applications. LTC/GAIA has developed a full range of high performance cells in both prismatic and cylindrical formats.

Yasunori Ozawa of ENAX, reported on development of lithium-ion batteries for electric bikes. The 36V, 7Ah battery uses prismatic pouch 3.6V, 7Ah cells. The battery has energy density of 235Wh/l and a specific energy of 118Wh/kg. ENAX is currently selling this bike and various other battery products in Japan.

The conference closed with a presentation by **John Broadhead** of Battery Intelligence™ Inc., on the use of "fuzzy logic" to monitor the state of charge (SOC) and state of health (SOH) of various battery chemistries. His discussion described various methods developed and techniques used for improving the monitoring of battery systems and improving the ability to predict performance trends in the systems.



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MEETING REPORT

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Around
 The Industry

Product News

Patents

Previous Issue

ARCHIVED EDITIONS

EXCLUSIVES

MEETING REPORT

**BATTCON 2012
 International Stationary
 Battery Conference**
 Hollywood, GA
 USA

MEETING REPORT

**BCI 124th Convention &
 Power Mart Trade Fair**
 Scottsdale, AZ
 USA

MEETING REPORT

**29th Florida Battery
 Seminar
 Part 2**
 Ft. Lauderdale, FL
 USA

PHOTO REPORT

**29th Florida Battery
 Seminar
 Part 1**
 Ft. Lauderdale, FL
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U. S. BATTERY AND FUEL CELL PATENTS

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Official Gazette, Volume 1281 (April 2004)

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U.S. 6,724,170 (20040420), Interconnect system for rechargeable computer batteries, Kevin Maggert, Charles Friedli, Due Q. Huynh, and William Kiger, Motorola, Inc.

U.S. 6,724,171 (20040420), Movable plug-head charger, Hanbai Wang and Kuanglung Yang, Primax Electronics Ltd. (TW).

U.S. 6,724,172 (20040420), Method for determining a maximum charge current and a maximum discharge current of a battery, Jaeseung Koo, Hyundai Motor Co. (KR).

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