BATTERY POWER

Solutions for OEM Design Engineers, Integrators & Specifiers of Power Management Products

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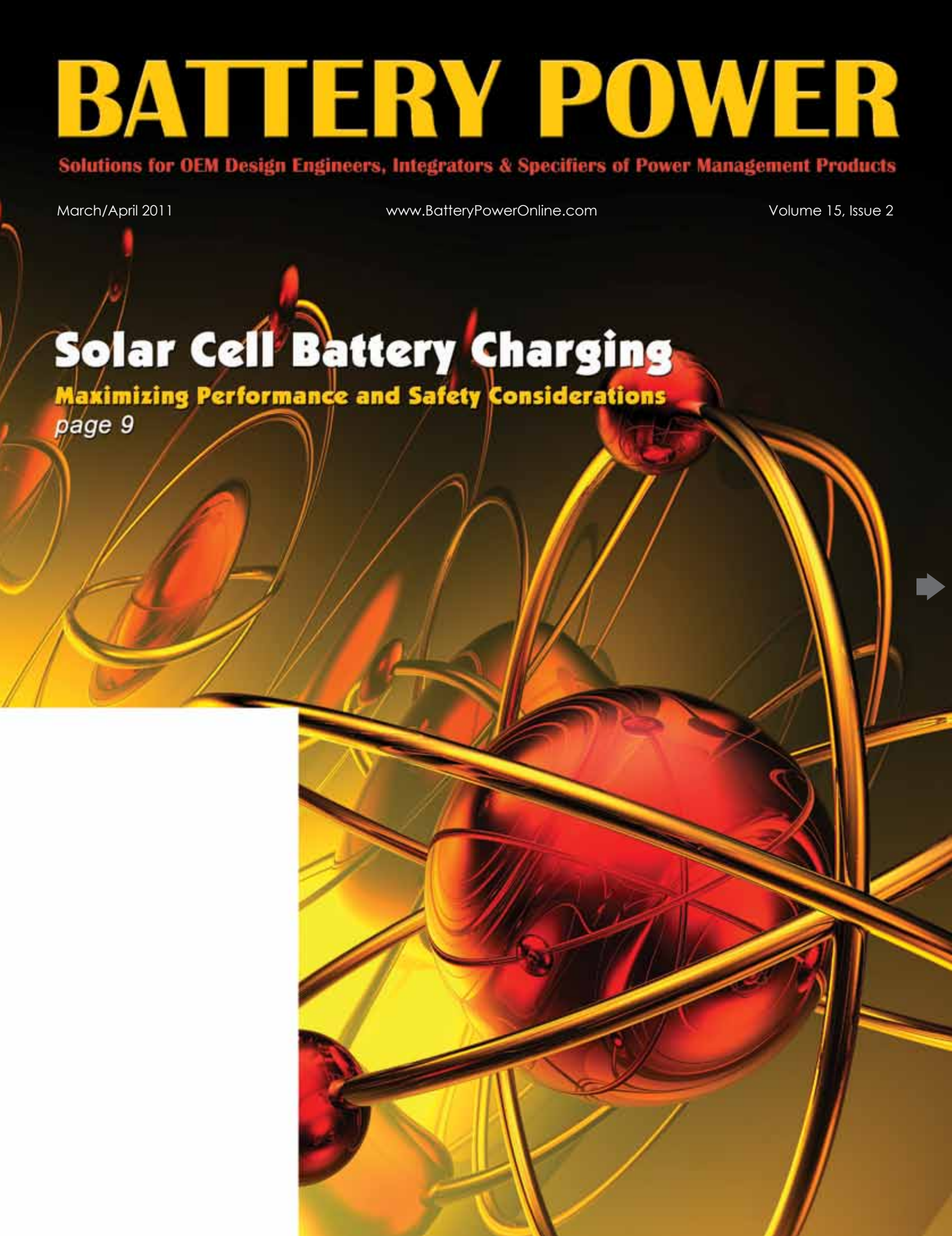

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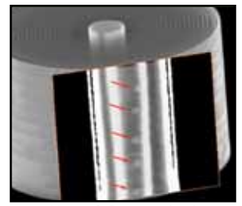

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Editor's Choice

Xtreme Power and Xcel Energy Partner with SolarTAC on Utility-Scale Solar-to-Battery Distribution Project

Xtreme Power, Inc., provider of Dynamic Power Resources (DPRs) for utility-scale energy storage, and Xcel Energy have partnered to install a 1 megawatt (MW) system to collect operational data on the integration of energy storage and solar energy systems at the Solar Technology Acceleration Center (SolarTAC).

SolarTAC is a private facility in Aurora, Colo. that serves as a solar industry test bed to validate and demonstrate a variety of solar technologies. The role of Xtreme Power's DPR is to perform a number of energy storage and grid asset functions including output smoothing, time shifting and forecast error mitigation for solar energy generated at the site.

The project aims to display the real-world results of integrating storage systems with solar installations, to more efficiently incorporate energy output from renewable sources onto the power grid. Results will be made public to reflect the system's performance over the course of three years.

"Taking part in the SolarTAC project with Xcel Energy affords us an opportunity to work alongside one of the most progressive utilities in the industry," said Carlos Coe, CEO of Xtreme Power. "We expect the results to highlight the broad range of benefits battery energy storage brings to PV manufacturers, project developers and power producers, ultimately enabling a more effective utilization of clean energy around the world."

"We hope that this demonstration will prove to be a pivotal point for PV solar energy combined with energy storage, and in turn underscore for utilities and other electricity providers that viable energy storage systems can become a commercial reality," said Frank Novachek, Xcel Energy director for business planning.

The DPR will be operational at the site by the end of 2010.

Rice University Researchers Build Microbatteries with Nanowire Hearts

Rice University researchers have moved a step closer to creating robust, three-dimensional microbatteries that would charge faster and hold other advantages over conventional lithium-ion batteries. They could power new generations of remote sensors, display screens, smart cards, flexible electronics and biomedical devices.

The batteries employ vertical arrays of nickel-tin nanowires encased in PMMA, a widely used polymer best known as Plexiglas. The Rice laboratory of Pulickel Ajayan found a way to reliably coat single nanowires with a smooth layer of a PMMA-based gel electrolyte that insulates the wires from the counter electrode while allowing ions to pass through.

"In a battery, you have two electrodes separated by a thick barrier," said Ajayan, professor in mechanical engineering and materials science and of chemistry. "The challenge is to bring everything into close proximity so this electrochemistry becomes much more efficient."

Ajayan and his team feel they've done that by growing forests of coated nanowires, millions of them on a fingernail-sized chip, for scalable microdevices with greater surface area than conventional thin-film batteries. "You can't simply scale the thickness of a thin-film battery, because the lithium ion kinetics would become sluggish," Ajayan said.

"We wanted to figure out how the proposed 3-D designs of batteries can be built from the nanoscale up," said Sanketh Gowda, a graduate student in Ajayan's lab. "By increasing the height of the nanowires, we can increase the amount of energy stored while keeping the lithium ion diffusion distance constant."

The researchers, led by Gowda and postdoctoral researcher Arava Leela Mohana

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Reddy, worked for more than a year to refine the process.

"To be fair, the 3-D concept has been around for a while," Reddy said. "The breakthrough here is the ability to put a conformal coat of PMMA on a nanowire over long distances. Even a small break in the coating would destroy it." He said the same approach is being tested on nanowire systems with higher capacities.

They have built one-centimeter square microbatteries that hold more energy and that charge faster than planar batteries of the same electrode length. "By going to 3-D, we're able to deliver more energy in the same footprint," Gowda said.

They feel the PMMA coating will increase the number of times a battery can be charged by stabilizing conditions between the nanowires and liquid electrolyte, which tend to break down over time.

The team is also studying how cycling affects nanowires that, like silicon electrodes, expand and contract as lithium ions come and go. Electron microscope images of nanowires taken after many charge/discharge cycles showed no breaks in the PMMA casing, not even pinholes. This led the researchers to believe the coating withstands the volume expansion in the electrode, which could increase the batteries' lifespan.

Photo Courtesy of Lockheed Martin Space Systems Company

ABSL Space Products is Chosen by Lockheed Martin To Deliver Lithium-Ion Batteries for the GeoEye-2 E

ABSL Space Products has been selected by Lockheed Martin Space Systems Co. to design, fabricate, test and deliver a test battery and quad-module lithium-ion battery for the GeoEye-2 spacecraft during a 20-month contract period. The batteries will build on ABSL's CryoSat-2 satellite and Earth Observation System (THEOS) spacecraft battery heritage to provide critical power solutions to the GeoEye-2 satellite during all phases of mission operation.

During GeoEye-2's seven-year on-orbit mission, each ABSL battery will provide 28 V bus power for eclipse operations as well as peak power imaging operations during it sun-synchronous orbit. It is projected there will be more than 38,000 cycles throughout the life of the mission. ABSL's battery heritage technology is proven to produce reliable lithium-ion batteries available for space flight with 70 spacecraft launched and more than 29,000 cell years of space operation without failure.

Lockheed Martin Space Systems Co. was chosen to design and build the GeoEye-2 satellite on Mar. 11, 2010 by GeoEye, a Dulles, Virginia-based company with operations in Thornton, Colo. The next generation GeoEye-2 satellite will be capable of resolving images on the Earth's surface within 0.33 meters at Nadir (with 652 km orbit); a level of accuracy currently unavailable by any existing commercial imaging satellite. The GeoEye-2 satellite will be launched in early 2013 aboard an Atlas V rocket provided by Lockheed Martin Commercial Launch Services.

ON Semiconductor Completes Acquisition of Sanyo Semiconductor from Sanyo Electric

ON Semiconductor Corp. has completed the acquisition of Sanyo Semiconductor Co., Ltd., a subsidiary of Sanyo Electric, and other assets related to Sanyo Electric's semiconductor business. Under the terms of the purchase agreement, ON Semiconductor paid approximately $144 million in cash to Sanyo Electric and drew down approximately $378 million under a loan agreement with Sanyo Electric.

"The combination with Sanyo Semiconductor represents an important step in the continued transformation of ON Semiconductor into a premier global supplier of high-performance silicon solutions for energy efficient electronics," said Keith Jackson, president and CEO of ON Semiconductor. "This acquisition enables us to expand wholeheartedly into the Japanese market and to capture growth on a global basis. We believe this acquisition will create immediate value for customers, partners and investors, and we are excited to welcome the employees of Sanyo Semiconductor to the ON Semiconductor family."

With the addition of Sanyo Semiconductor, ON Semiconductor expands its product portfolio, adding new capabilities ranging from microcontrollers and custom Application Specific Integrated Circuits (ASICs) to integrated power modules and motor control devices for the consumer, automotive and industrial end-markets.

ON Semiconductor plans to operate Sanyo Semiconductor as an independent division, utilizing the Sanyo logo for up to three years. However, plans are already underway to begin offering both ON Semiconductor's and Sanyo Semiconductor's products and technologies to all worldwide customers.

Tesla Launches Battery Recycling Program Throughout Europe

Tesla Motors has launched a comprehensive strategy to recycle its battery packs throughout Europe. At the end of their life, Tesla will recycle its battery packs at Umicore's UHT facility in Belgium. The Brussels-based materials technology company will use the expended pack material to produce an alloy that will be further refined into cobalt, nickel and other metals.

After that, Umicore will transform the cobalt into high grade lithium cobalt oxide, which can be resold to battery manufacturers. One of the few byproducts of their environmentally-friendly approach is a clean inertized slag containing calcium oxides and lithium. The slag goes into the production of special grades concretes.

Umicore's battery recycling technology allows to save a

minimum of 70 percent on CO_2 emissions at the recovery and refining of these valuable metals. So it can substantially reduce the carbon footprint for the manufacturing of Lithium-Ion batteries.

Micro Power Announces Iron Phosphate Battery for Replacement of Sealed Lead Acid Batteries

Micro Power has released IronWorks, a patent pending Iron Phosphate battery solution, which serves as a drop-in replacement for Sealed Lead Acid (SLA) batteries. Manufacturers of mobile equipment can now achieve lighter weight, longer runtime, faster charge time and longer cycle life with this new standard U1 format battery. IronWorks is based on Lithium Iron Phosphate, a safe and environmentally friendly chemistry.

"Recent innovations in Iron Phosphate chemistry have made it extremely competitive in markets that are weight sensitive and inconvenienced by SLA's need for frequent maintenance," said Robin Tichy, product manager for IronWorks at Micro Power. "Many devices utilizing 12 V batteries for mobile power, such as medical carts or computers-on-wheels, are prime targets for direct replacement of SLA batteries with IronWorks, which offers thousands of cycles, reduced maintenance time and costs, and a far lower total cost of ownership over the lifetime of a product."

IronWorks attributes include thousands of cycles with full 100 percent discharge, zero maintenance for several years and fuel gauging and battery status reported via standard SMBus.

Envia Systems Delivers High Energy Density Battery Materials Available for Commercial Testing

Envia Systems has released its high capacity manganese rich (HCMR) cathode material for advanced batteries is available in limited quantities for pilot vehicle programs.

Envia's HCMR technology is the first of its proprietary cathode and anode materials for Li-Ion batteries to be readied for commercial testing. Envia's HCMR cathode material enables batteries that are distinct in five primary ways: using low cost safe materials, delivering unmatched energy density, providing improved cycle life and offering an inherent ability to customize battery size and output in order to meet the demands of a variety of applications, particularly EVs and PHEVs.

Envia's HCMR cathode has twice the capacity over currently available cathode materials. This capacity doubling enables battery-makers to make much smaller battery packs that can reduce the costs of EVs and PHEVs.

"Offering Envia's HCMR technology for pilot vehicle programs is a major milestone in the commercialization of higher-performance lithium ion cells," said Dr. Sujeet Kumar, founder and CTO of Envia Systems. "HCMR is the first next-generation solution to leverage Argonne National Laboratory's composite cathode material, licensed by Envia."

"The relationship between Argonne and Envia dates back to 2008, when we collaborated to make cathode material in small quantities. This collaboration is a demonstration of the extraordinary impact and value of Department of Energy's investment in basic research, and shows the very real contribution the national laboratories make to our country's prosperity," said Dr. Jeff Chamberlain, head of Argonne's Energy Storage Initiative.

"The future of the automotive industry is heavily invested in the affordability of EVs and PHEVs," said Michael Sinkula, co-founder of Envia Systems. "Energy storage is the key element to reducing costs. Throughout the past three years, Envia has assembled a unique, interdisciplinary team whose expertise in material sciences and electrochemistry has been crucial in attacking the challenge of high-density, low-cost energy storage."

New Overhead Bus for Eltek Valere's Scalable Powerpack Plant Eliminates Need for Central Overhead Bus Detail

Eltek Valere has announced the next generation (Gen3) of its scalable power product family, the Scalable Powerpack, a fully integrated DC power system for central offices, mobile telephone switching office (MTSOs), data centers and other high-capacity computing/networking centers.

The Scalable Powerpack is a highly reliable, fully configurable system designed to minimize both installation and operational costs while delivering maximum power conversion efficiency. This latest Gen3 model utilizes high-capacity Powerpack rectifiers, incorporates an overhead bus that enables easier cabling installation, reduces cable congestion inside the bay and eliminates the need for costly central bus details or chandeliers.

The Scalable Powerpack system can scale up to 10,000 amps and is optimized for facilities where high power needs and ease of expandability are important. The central building block is Eltek Valere's three-phase, 48 V Powerpack rectifier, which is rated at 200 A with high power efficiency conversion exceeding 94 percent. Powerpack rectifiers are available in 208 VAC or 480 VAC input configurations and utilize three-phase power.

Solar Cell Battery Charging

Maximizing Performance and Safety Considerations

Michael Day and Javed Casey, Power Management Group
Texas Instruments

Solar cells are a very popular solution for providing cheap, green energy. They are useful in applications where standard AC line power is not available, or where the power grid is intermittent and unreliable in rural areas such as parts of India and other developing nations. A typical system might be designed to use a solar cell for charging a battery during daylight hours, and then allow the battery to power the end application such as a solar-powered lantern during the night or under cloudy conditions.

Using extremely simple, inexpensive charging circuits to connect the solar cell to the battery does not efficiently convert solar power into usable energy and can damage the battery due to over- and under-charge conditions. A well-designed charging system should maximize the solar cell energy to minimize both the size and the cost of the solar cells. It should also provide battery protection circuitry to ensure the battery is only operated within its recommended limits. This ensures maximum battery life and protects against possible battery fire or an explosion.

Understanding a solar cell's operating characteristics is a necessary component to optimize overall system efficiency. Figure 1 shows a solar cell's V-I curve.

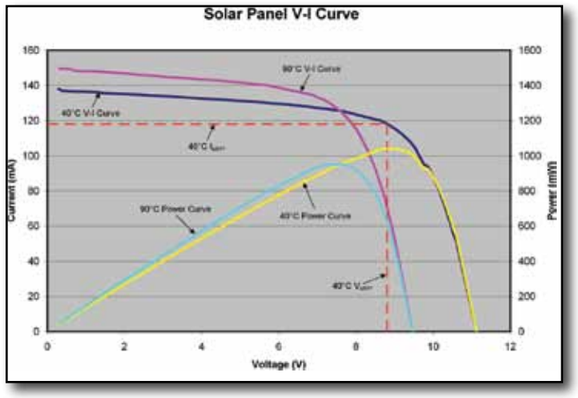

Figure 1. Solar Panel V-I Curve

The highest solar cell voltage occurs with an open circuit. No power is delivered at this operating condition. The highest current occurs with a short circuit, but no power is delivered at this operating condition either. This implies that the solar cell must have a maximum power point (MPP) somewhere between these two conditions. Figure 1 displays the solar cell's output power versus operating voltage. The power traces are calculated by multiplying the current-axis and x-axis. A properly designed system should operate at the solar cell's MPP. Conceptually, it is fairly easy to operate at this point simply by designing the solar cell's load to consume any amount of current up to the solar cell's MPP current, but no more than this.

For a standard Lithium-Ion (Li-Ion) battery charger operating in constant current-charge mode, often called fast charge [1], the battery charger delivers a constant current to the battery, independent of battery voltage. This works well with a standard power source to the system because these sources are typically well-regulated and their current capability exceeds that which is needed by the charger. A solar cell's operational characteristics provide a challenge in battery-charging applications. Operating at too low of a current does not efficiently use the solar cell's power capability. Operating at too high of a current causes the solar cell voltage to drop too low to be usable. Consider three different operating points in fast-charge mode.

The first operating point is defined where the load pulls less current than the solar cell's IMPP. This operating point ensures that the solar cell's voltage does not drop too low, but does not pull the maximum power available from the solar cell. If the system load only requires a current that is less than the solar cell's IMPP, then there are no drawbacks to operating at this point. However, if the user artificially sets the maximum available current lower than IMPP, the solar cell power is not fully utilized and the system takes longer to charge the battery than necessary.

The second operating point occurs when the load pulls more than the solar cell's IMPP. At this point, the solar cell voltage drops and reduces the available power. If the load tries to pull too much current from the solar cell, the voltage eventually collapses, halting any charge to the battery. The current then drops and the solar cell voltage rises, allowing the charger to start the process all over again. This operation significantly reduces the solar cell's available power because the system spends a large percentage of its time either turned off or restarting.

The third operating point is defined at the solar cell's MPP where the system takes full advantage of the solar cell's maximum output power capability. This design allows the load (battery and system) to pull its required current, but only up to the solar cell's IMPP.

A battery charger specifically designed for solar cell charging applications with built-in functionality helps to operate a solar cell at its MPP. In addition to the normal internal control loops designed to maintain the battery's voltage and current regulation, a solar cell charger has an additional control loop. The maximum power point tracking (MPPT) loop monitors the solar cell output voltage and overrides the other control loops, if the system tries to pull too much current. When the system consumes less than the solar cell's MPP, the solar cell's output voltage is above VMPP and this loop becomes inactive. As the system pulls more current, the solar cell's output voltage drops. When it drops to its VMPP, the MPPT control loop overrides the existing control loops and regulates the maximum solar cell current to maintain the solar cell voltage at VMPP. This function allows the system to pull up to, but not more than, the solar cell's maximum output power. When the system load decreases, the MPPT control loop is disabled and standard charger control resumes.

Operating at the solar cell's MMP is a simple task at any specific temperature. Unfortunately, a solar cell's MPP changes with temperature. Figure 2 shows this change in MPP over temperature.

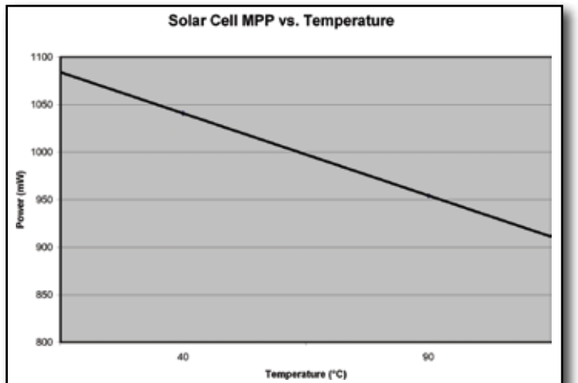

Figure 2. Solar Cell MPP Versus Temperature

A charger designed with a fixed MPP under-utilizes a solar cell's available power when operated at any temperature other than the specific temperature for which it was designed. This requires larger solar cells to achieve the same charge time. For example, when a charger with fixed MPP optimized for a solar cell's 40°C MPP is operated at 90°C, it operates the solar cell well below its 90°C MPP. Under these conditions, the solar cell only provides approximately 75 percent of its available power. Figure 3 shows a circuit that uses a negative temperature coefficient (NTC) resistor to adjust the charger's MPPT voltage setting across changes in temperature. This allows the charger to track the solar cell's MPP and fully utilize all available power across temperature variations. Properly selecting the component values is fairly complicated, but an Excel spreadsheet [2] is available to help you through the process.

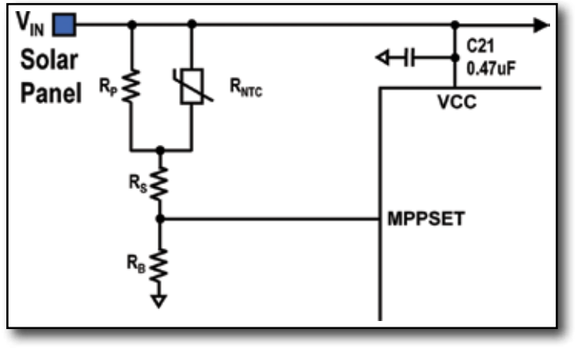

Figure 3. Temperature Compensated MPP Tracking Circuit

Using the design spreadsheet as a guide, we built and tested a temperature compensated MPPT circuit, again using the bq24650. The circuit is powered by a 13.6 V (VOC), 240 mA (ISC) solar cell. The MPPT circuit was tested, with and without temperature compensation, and connected to a 4.2 V, 160 mA-hr polymer Li-Ion battery. Optimizing the design for 40°C and operating the solar cell at 40°C results in a 74-minute charge time. However, when the actual operating temperature is increased to 90°C, the charge-time increases to 170 minutes, or a 130 percent increase. The same test conditions using the temperature compensating NTC circuit result in a 78-minute charge time at 40°C, and a 100-minute charge time at 90°C.

Although the longer charge time at 90°C is expected because a solar panel's power capability drops with increasing temperature, the NTC temperature compensated circuit provides a 41 percent reduction in charge time, versus not using a fixed-temperature design. Figure 4 shows charge time versus temperature for both a fixed 40°C optimized charge circuit and a NTC temperature compensated charge circuit. Because the temperature compensated design maximizes solar cell power at all temperatures, it always provides a reduction in charge time.

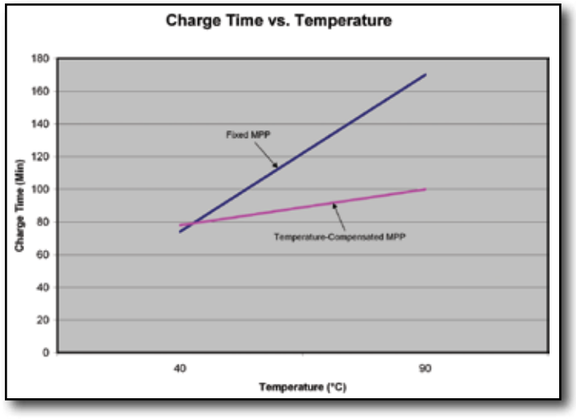

Figure 4. Charge Time Versus Temperature

While solar panel power utilization and charge times are always important design specifications, battery life and safety also need to be considered. Frequent over-charging or discharging significantly reduces a battery's lifetime. Extremely discharged Li-Ion batteries must be slowly conditioned with a trickle charge before a full-charge cycle can begin. Although not dangerous, applying full-charge current to a heavily discharged battery

reduces its lifetime.

Select a battery charger that provides a pre-charge threshold to properly condition the battery prior to entering the fast-charge mode. Overcharging a Li-Ion battery can have serious consequences that range from simply reducing battery life to potential explosion. To quantify this, repeatedly overcharging a Lithium Cobalt- ($LiCo0_2$) based battery by only 150 mV above the recommended level reduces the battery capacity by 50 percent in only 200 charge cycles. A single 300 mV overcharge can result in catastrophic failure, resulting in fire or explosion. With a tightly regulated charge voltage of +/–0.5 percent, chargers like the bq24650 ensure safe charging voltages and maximum battery life. Charging above and below recommended charging temperatures is also dangerous and can reduce battery life. Look for a solar battery charger that incorporates circuitry that qualifies the battery temperature and either prevents charging or suspends charging, if the temperature falls outside of the design limits.

Summary

Fully utilizing solar cell power capability, maintaining safe battery charge voltages, and qualifying allowable charging temperatures are important design parameters in a solar-charging application. Simple, discrete charge circuits do not provide the required functionality needed to meet these design requirements. Designers should turn to ICs specifically designed for this type of application. Their maximum power point tracking circuitry reduces solar cell size requirements and battery charging time while their built-in safety circuitry maintains battery life and ensures the safety of the system.

References

1. Download a datasheet for the bq24650 here: www.ti.com/bq24650-ca.
2. BQstroller calculation tools: www.ti.com/bqstrollertool-ca.
3. For more information about other solar solutions from TI, visit: www.ti.com/solar-ca.
4. See videos, ask questions and share knowledge on the TI E2ETM Community: www.ti.com/e2e-ca.

Michael Day, Power Management Application supervisor for Texas Instruments' Power organization, has 16 years design experience in the field of power conversion. Currently, Michael manages the DC/DC Power Applications group at TI. He received his BSEE and MSEE in Pulsed Power from Texas Tech University, Lubbock, Texas. Michael is a member of IEEE and has published more than 60 articles on power, portable power and lighting topics.

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Lithium-Ion Battery – Potential Business Opportunities

Vishal Sapru, Research Manager Power Supplies & Batteries
Frost & Sullivan

The US is a significant market for lithium-ion batteries for consumer, industrial and automotive applications in the North American region. The economic recession had a significant impact in the demand for lithium-ion batteries, particularly for consumer and industrial portable devices. This was witnessed by a decline in demand during the first two quarters of 2009, caused by decreasing demand for consumer electronic devices in the US.

However, signs of recovery began from the third quarter of 2009, with industrial application showing quick revival and consumer applications gaining strength. Impact of economic crisis was minimal in the demand for batteries used for military and medical application. For the automotive lithium-ion battery market in the US, the economic recession has had minimal impact on the industry advancement and growth.

The US lithium-ion battery market continues to evolve as high power and high capacity cells increase penetration into large-format applications. For large-format applications such as grid energy storage, aerospace/defense and others, competition among battery chemistries is intense. Many advanced battery and alternative energy storage solutions such as flywheel and fuel cells are vying for market adoption. However, key performance characteristics have enabled lithium-ion to make in-roads into the market, resulting in increased growth opportunities.

Growth Opportunities for Lithium-Ion Batteries

Grid/Utility Energy Storage: Although not in use today, high-power, energy-dense lithium-ion batteries are considered a viable option for future grid energy storage solutions. The US market for utility-scale lithium-ion batteries is lucrative and expected to generate significant market opportunities.

For utility applications, currently stationary lead acid batteries are the most commonly used energy storage technology in reserve power systems for switchgear and instrumentation control systems in electric utilities. These power systems offer emergency backup power to power generation plants, including fossil fuel, hydro, and nuclear power plants, as well as switching substations. Since a power outage in a utility system would result in serious complications along with heavy revenue loss both at the supplier end and the distributor end, high priority is given to maintaining continuous power supply through a backup system. This makes backup systems with efficient, reliable and

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Use of Computed Tomography Scanning for Defect Detection in Lithium-Ion Batteries

Troy A. Hayeş, Celina J. Mikolajczak, Marcus V. Megerle, Ming Wu • *Exponent Failure Analysis Associates, Inc.*
Shirish Gupta • *Dell*
Phil Halleck • *Pennsylvania State University*

It has become clear with continuing lithium ion (Li-Ion) battery recalls, many of which are reportedly due to metallic particles within battery cells, that contaminants within a Li-Ion battery cell can have detrimental effects. Such contaminants can cause a variety of problems ranging from very severe, such as thermal runaway in a cell, to fairly benign, such as a cell with a high self-discharge rate. While the critical size and morphology of a particle required to cause severe problems is not well known, the size scale of interest is generally believed to be in the range of 20 µm to 100 µm. Most separators are approximately 20-µm thick, and though piercing of the separator alone is considered unlikely to cause cell thermal runaway between anode and cathode due to the relatively high impedances of anode and cathode active material, the presence of such a particle would likely result in micro-shorting within the cell. Such a cell would likely suffer from a high self-discharge rate. The distance between the current collector of one electrode (the aluminum current collector) and the active material of the opposite electrode (the carbon of the anode) is on the order of 20 µm for locations where bare aluminum (Al) current collector is adjacent to the anode or 100 µm where the anode is adjacent to the cathode. Zhang, et al [1] showed that low impedance contact (as would be formed by a metallic contaminant) between the Al current collector and anode active material (particularly fully lithiated carbon) can produce significant heating within a cell and potentially lead to cell thermal runaway. "Large" contaminants, if present between the windings upon testing, are generally expected to be detected by Hi-Pot testing (high-voltage application across the windings prior to the addition of electrolyte) during cell production.

Battery manufacturers continually try to improve not only the methods to minimize the risk for detrimental contaminants when building Li-Ion cells, but also the methods by which such contaminants can reliably be detected. Presently, the most common nondestructive technique that is used to visualize the internal components of a battery after full assembly is X-ray. A technique that is utilized by some manufacturers for research and development (R&D) as well as failure analysis is CT scanning. Exponent commonly uses CT scanning to examine the internal structures of batteries as part of design reviews, cell evaluations and/or failure analyses. This article will evaluate the ability of these two techniques in identifying contaminants in cylindrical 18650 wound Li-Ion cells.

Experimental Methods

Battery cells containing two different types of defects were analyzed in this study. Battery cells examined in this study were cylindrical 18650s (18-mm diameter, 65-mm length) with carbon anodes and lithium cobalt oxide (LCO) cathodes. The cells were all first examined using a high-resolution X-ray machine before using a microfocus CT scanning machine. CT scans were conducted at voltages of 130 kV to 140 kV in three-line scanning mode (moderate resolution). The resulting slice thickness of each scan cross section was 70 µm with an in-plane resolution of 20 by 20 µm. A complete cell scan for an 18650 cylindrical cell consisted of approximately 1,000 slices and took approximately seven hours to complete, or approximately 25 seconds per slice. Scanning was repeated on two of the cells containing contaminants (see Case 1) at 100 kV in single-line scanning mode (high resolution) for comparison. For these scans, the slice thickness was 23 µm and the total scan time for a single cell was approximately 18.5 hours.

Case 1

For research purposes, four dry cylindrical 18650 lithium ion battery dummy cells with a carbon anode and LCO cathode were wound containing a specific distribution of known metallic contaminants. No Hi-Pot testing was conducted on these windings and no electrolyte was added, but otherwise these windings were assembled as normal into 18650 cells. The cells were made with metallic contaminant particles of Al, copper (Cu) and nickel (Ni), all elements that are commonly found as constituent materials in Li-Ion cells, as well as iron (Fe), a common contaminant found in anode and cathode material as well as the manufacturing process. Cells A, B, C and D were built with Al, Fe, Ni, and Cu particles, respectively. Three sizes of particles were placed in the cells: small (50 by 50 by 20 µm), medium (100 by 100 by 50 µm) and large (500 by 500 by 100 µm) at known locations.

Each of the battery cells were examined using a high-resolution X-ray machine in order to determine whether the location of the particles could be identified using this analytical technique. Battery cells were examined at 10° increments over a 180° rotation on the top half of the cells (where the contaminants were known to be present). Images were acquired if any changes in contrast were identified during real-time observation that were consistent with the presence of a contaminant. This examination approach required approximately six hours to complete (1.5 hours per cell).

Each of the battery cells was then examined using moderate-resolution CT scan, and the resulting images were analyzed to determine whether the location of the contaminants could be identified. Cells A and B were scanned a second time using high-resolution mode for comparison. In the CT scan images, high-density regions appear bright, while low-density regions appear dark (the reverse of a traditional X-ray image). In Li-Ion batteries examined, the Cu current collectors appear as thin bright lines. The cobalt oxide cathodes appear as thicker lines.

Case 2

A cylindrical 18650 battery cell from a field return battery pack where individual cells had experienced capacity loss and repeated severe over-discharge were examined. The cell had a carbon anode and LCO cathode. While the specific level of over-discharge is unknown (over-discharge occurred during use in the field), the cells were determined to have experienced Cu dissolution as a result of the repeated over-discharge, which occurs when the overall cell potential reaches approximately 1.5 V or below [2 to 4]. Cell over-discharge may cause copper dissolution to the point that numerous holes form in the Cu current collector.

Results

Case 1

Particle detection using planar X-ray imaging was very straight forward for the "large" Fe (Figure 1), Ni, and Cu particles, but was not possible for the Al particles. Detection was not possible using planar X-ray for the medium or small particles of any of the contaminant materials.

Figure 1. Planar X-ray of "large" iron (Fe) particles inside Cell B.

Examination of the cells using CT scan allowed positive identification all but one of the contaminant particles of Fe, Ni and Cu (one of the smallest Fe particles could not be identified). An example of CT cross sections showing the largest particles is shown in Figure 2. Because of its low density and atomic number, identification of Al particles via CT scan, even when quite large, can be challenging. While the large particles could be identified in individual cross sections created during the CT scan, their size played as much a role in its positive identification as their visual contrast due to the formation of an apparent void in the windings. This may be improved by scanning with a lower scanning voltage and higher current, which would improve contrast. By adjusting the visualization contrast in the CT scan images (without adjusting the actual imaging conditions) and taking a vertical cross section of the cell at the appropriate location, the Al particles become quite pronounced (Figure 3). No medium-sized Al particles could be identified using these techniques.

CT scanning easily identified the large particles of Fe, Ni, and Cu in the horizontal cross sections generated by the CT scan (Figure 2). For the medium particles; however, it was apparent that Fe was sometimes difficult to detect in the horizontal cross sections generated during CT scanning and may not have been

positively identified if the approximate location had not been known prior to the examination. Similar to the technique used to enhance the detectability of the large Al particles, when the contrast (and coloration here) of the CT scan images is adjusted and a vertical CT cross section is taken, the medium-sized Fe particles become quite clear (Figure 4). Particles are more readily apparent in the vertical cross sections than the horizontal cross sections because the long dimensions of the particles lie vertically, resulting in a greater number of pixels appearing for each particle. Enhancing the contrast/color also appears to be an effective method to highlight the smaller particles. It may be possible to set up a computer algorithm that could automatically detect the presence of such particles based on the image contrast variation; however, this was not attempted here. While none of the smallest Fe particles could be identified during the examination of the horizontal CT cross sections, four of the five particles could be detected using the vertical cross section with color contrasting. It is possible; however, these particles would not have been detected if their approximate location were not known in advance.

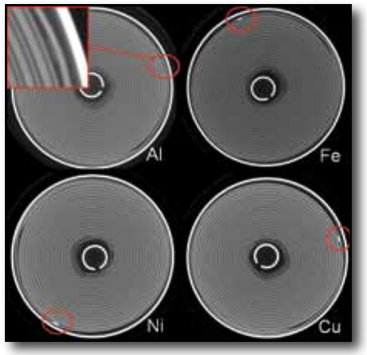

Figure 2. CT scans of the large particles detected in Cells A through D.

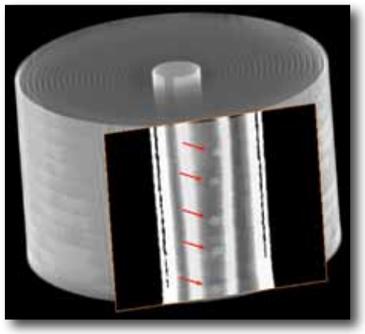

Figure 3. Vertical CT cross section of Cell A illustrating the presence of the large aluminum (Al) particles.

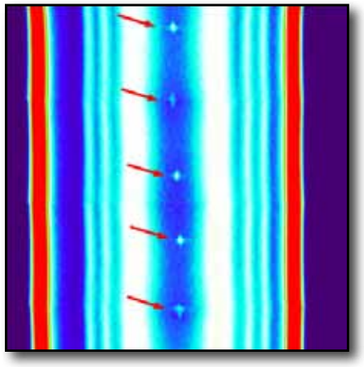

Figure 4. Vertical CT cross section of Cell B with color contrast illustrating the presence of the "medium" iron (Fe) particles.

This suggests that the smallest Fe particle that can be expected to be detected using CT scanning is on the order of, but slightly higher than 50 by 50 by 20 µm.

The detection limit for Ni is somewhat better than for Fe. All medium Ni particles were clearly visible during the examination of the horizontal cross sections and much more pronounced when using the vertical cross section. None of the small Ni particles were visible during the preliminary examination of the horizontal CT cross sections, however all five of the smallest particles are visible in the vertical cross section with color contrast. This indicates a detection limit is on the order of 50 by 50 by 20 µm.

All medium Cu particles were easily detected in the original horizontal cross sections. In addition, three of the five smallest Cu particles were identified during the initial examination of the horizontal cross sections, but detection without prior knowledge of the location would be difficult if not impossible. All five small particles were visible using vertical cross section with color contrast. This indicates a detection limit is on the order of 50 by 50 by 20 µm.

High-resolution scanning of Cells A and B resulted in only slightly better detectability. Medium and small Al particles were still undetectable in Cell A. One of the small Fe particles could be detected in the high-resolution horizontal cross sections, but only because the location of the particle was known. The particle would most likely be undetectable by inspection or by computer under normal circumstances and is not shown here because the image contrast of the particle is so poor that it would not prove useful to present it in this form.

Case 2

Two 18650 cells that had been subjected to repeated deep discharge (over-discharge) appeared normal via planar X-ray (e.g., left image of Figure 5). While both cells had experienced some cap leakage and internal corrosion as evidenced by the mottled appearance in the bottom (cap region) of the image, nothing about the cell windings appeared to be out of the ordinary. CT examination (right images of Figure 5) shows that the Cu current collector appears discontinuous throughout the cell, broken by a series of small gaps or holes, with diameters in the plane of the cross section on the order of the current collector thickness (approximately 15 µm). These types of holes have been confirmed to be the result of copper dissolution. Upon cell unrolling, it was determined that these holes were typically of the order of the thickness of the anode electrode (coated anode/Cu current collector layer), or 100 µm in size. During the same examination, CT scanning revealed another feature that was not identified by planar X-ray: pronounced delamination of the cathode material (lower right image in Figure 5).

Discussion

In addition to the features discussed here, we have found that CT scanning can easily identify other manufacturing defects within battery cells such as extra or missing cathode active material; torn or perforated Cu current collectors; folded or

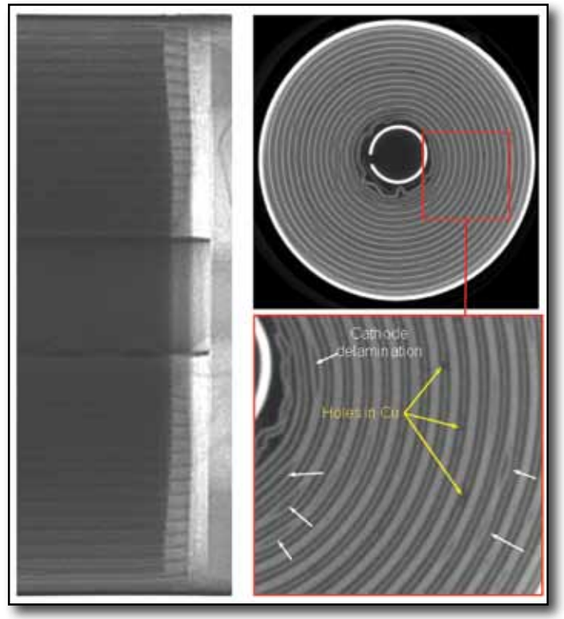

Figure 5. X-ray of cylindrical 18650 Li-ion battery cell that had been subjected to repeated deep discharging (over-discharging) (left) and CT scan images of the same battery cell (right).

wrinkled Cu current collectors and misaligned electrodes. While planar X-ray examination can quickly and effectively screen out some defects such as tab shape/positioning and global electrode misalignment with a single image, it is limited in its ability to screen for localized defects, even when significant numbers of planar X-rays are taken of a single cell because of the masking effect created by the inherent image averaging that occurs.

The CT scan is a very useful tool for non-destructive examination of battery cells for structural defects or contaminants. It is therefore a natural tool to use in the failure analysis of a failed field return cell and can provide useful information as a preliminary tool for examination of under-performing cells or cells that have failed performance or safety tests. It can be used to selectively evaluate production cells on a periodic basis as part of a comprehensive quality assurance (QA) program. The extensive scan time preclude the use of CT scanning as part of an in-line quality control (QC) procedure.

Conclusions

Microfocus CT scanning is a very powerful tool that can be used to evaluate the structural properties of common small-scale batteries of varying form factors and chemistries as demonstrated in this study using 18650-size Li-Ion batteries. CT scanning can detect physical defects in cells that cannot be detected using high-resolution X-ray. In this study, we determined that the approximate particle size that is detectable using moderate-resolution CT scanning in 18650 cylindrical LCO Li-Ion batteries is of the order of 500 by 500 by 100 µm for Al particles and 50 by 50 by 20 µm for Fe, Ni, and Cu particles. Detectability of contaminant particles by CT scan increases with increasing atomic number. In contrast, none of the Al particles were visible by high-resolution X-ray and only the largest particles were visible by X-ray for Fe, Ni and Cu. CT scanning was also shown to be capable of easily identifying cathode delamination and Cu dissolution in battery cells that have been severely over discharged, whereas neither of these features were visible by high-resolution X-ray. High-resolution CT scanning offers marginal improvements for detectability and dimensional measurement accuracy; however, the scan time increases from approximately seven hours to approximately 18.5 hours per full cell.

Acknowledgements

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Contour Energy Systems Launches Next-Generation Coin Cell Product Line

Contour Energy Systems, Inc. has launched of its next-generation coin cell product family with the introduction of the four top selling lithium coin cell sizes (2032, 2025, 2016 and 2450) featuring the company's patented Fluorinetic technology. Contour's new lithium coin cells, which deliver longer battery life and improved gravimetric and volumetric energy density compared to legacy primary lithium and rechargeable lithium ion batteries, are targeting a wide range of existing and emerging portable electronics and drug delivery systems.

As new versions of these diverse applications come to market with added features and capabilities that demand greater power densities, the need for next-generation coin cells capable of delivering new performance levels is escalating. Extended run time, improved discharge rates and longer shelf life are increasingly important considerations to consumers. Contour's Fluorinetic technology is delivering on each of these next-generation battery requirements.

Contour's new coin cell product line features three primary advantages: greater runtime, better discharge rates and longer shelf life compared to current lithium products. Contour's patented Fluorinetic technology leverages breakthrough lithium/carbon fluoride advancements to achieve these high energy and power densities. In addition, the advanced lithium/carbon-fluoride batteries overcome operational problems exhibited by some other lithium batteries, such as passivation, which has a significant voltage drop upon starting up a device.

NexSys Battery and Charger System Provides Enhanced Cycling Performance and Rapid Recharging

The EnerSys NexSys battery and charger system provides a flexible, virtually maintenance-free energy solution for small traction applications. Unlike conventional lead-acid batteries, NexSys batteries offer increased cycling performance and high rate recharging capability, contributing to longer service life and increased machine availability.

NexSys batteries feature positive and negative plates with low impedance, high corrosion resistant thin-plate grids manufactured from pure lead in a unique process. The NexSys battery offers high energy throughput up to three times the battery capacity per 24 hours, as well as an increased maintenance-free life cycle of up to 1,200 cycles at 60 percent depth of discharge (DOD). Additionally, the batteries feature a microporous glass mat separator with high electrolyte absorption and stability to enhance cyclic capability.

Complementing its virtually maintenance-free characteristics, the EnerSys NexSys battery withstands shock and vibration while providing eco-friendly performance. Its minimum gassing makes it well suited for use in shops, public areas and sensitive manufacturing areas. Additionally, NexSys batteries typically occupy up to 30 percent less space than the equivalent lead calcium batteries due to the thin plate design's high energy density properties. NexSys batteries have a long shelf life, up to two years at 77°F.

Energizer Energi To Go

Energizer Energi To Go is a portfolio of rechargeable lithium polymer power packs for those who want to keep work and entertainment devices powered outside the home or office. Included in the line are models designed to charge cell and smartphones, MP3 players, GPS units, Bluetooth, tablets, portable DVD players, digital cameras and camcorder batteries, netbooks and laptops. These sleek chargers are rechargeable up to 500 times and include a TipFit Guarantee, meaning Energizer guarantees it has a tip to fit any handheld gadget and they will charge even the hottest new gadgets for years to come.

Electrovaya Advances Smart Grid Storage Market With Lithium Ion Energy Storage System

Electrovaya, Inc. has launched a Lithium Ion Battery Energy Storage System product line. This Smart Grid product is now available to utilities and solves the most critical energy storage challenge for utilities today.

For utilities with increasing renewable generation, the Electrovaya system offers a compact, efficient and reliable solution to firm these intermittent generation sources. The Electrovaya product works by storing electrical energy from renewable energy or other sources during off-peak periods and then providing power at periods of peak demand.

Furthermore, for regions with increasing urbanization that require urban Peaker plants and/or added high voltage transmission lines, the Electrovaya product line provides a highly efficient, small footprint cost-competitive solution.

The Energy Storage System is based on Electrovaya's proprietary Lithium Ion SuperPolymer cell technology, which is well suited for large scale energy storage applications. Modular and scalable from 1 MWh to 100 MWh or more, the Energy Storage system is controlled and monitored by Electrovaya's iBMS, an intelligent battery management system. The Electrovaya system is capable of storing electricity at a round trip efficiency of about 90 percent. The product line is designed for minimized footprint and can be installed anywhere along the generation, transmission and distribution points of a utility system.

New EnerSys Express eMax HF Advanced High Frequency Fast Chargers

EnerSys has introduced the Express eMax HF fast chargers. Utilizing the latest innovations in high frequency charging technology, the eMax HF line of fast chargers have been rigorously engineered to provide the highest level of performance and efficiency available today while remaining amazingly compact and flexible.

The advanced high frequency technology behind the eMax HF fast charger means high charger efficiencies for lower operational costs and high power factors, which substantially reduce AC line draws lowering infrastructure investment. The innovations used in the charger design result in the most compact charger footprint on the market today yielding more valuable floor space.

Always connected and fully networked, the eMax HF fast charger comes standard with a sophisticated wireless communications interface making real time battery and charger fleet management a reality. Express Fast Charge Systems feature the optional Motive Power Manager, an information management system, which provides remote alerts and reports so users can manage assets with precision and achieve even more savings from day one.

New Legacy Titanium HF Charger by Douglas Battery

Douglas Battery has introduced the new Legacy Titanium HF Charger. Utilizing advanced High Frequency Insulated Gated Bipolar Transistor (HF IGBT) charging technology, the Legacy Titanium HF charger delivers the high power factor and high efficiency that reduces utility demand charges and AC consumption.

The combination of HF IGBT technology and the exclusive charging profile of the Legacy Titanium HF charger constantly diagnoses a battery's condition and adjusts the charge. The result is a full and accurate charge every day, no matter what the depth of discharge.

Several HF IGBT advantages include reduced costs, reduced maintenance and a wide range of battery charging capacities. The Legacy Titanium HF charger is a well suited choice for tubular, flat plate and flooded lead acid batteries.

Alpha Unveils ACS125HP, Industrial-Grade Modular Charging System

Alpha Industrial Power, an innovator in the development of industrial-grade powering solutions and a member of The Alpha Group, has released its new modular, high performance powering system, the ACS125HP.

As a standard feature of Alpha's new ACS125HP Charging System, the Cordex communication and monitoring control package provides complete access to battery management, data logging, daily statistics and charger system control. System management is a simple single-step process using either the Cordex CXC touch screen system controller or an Ethernet connection and any Internet browser.

Cadex Electronics Introduces the C8000 Battery Test System

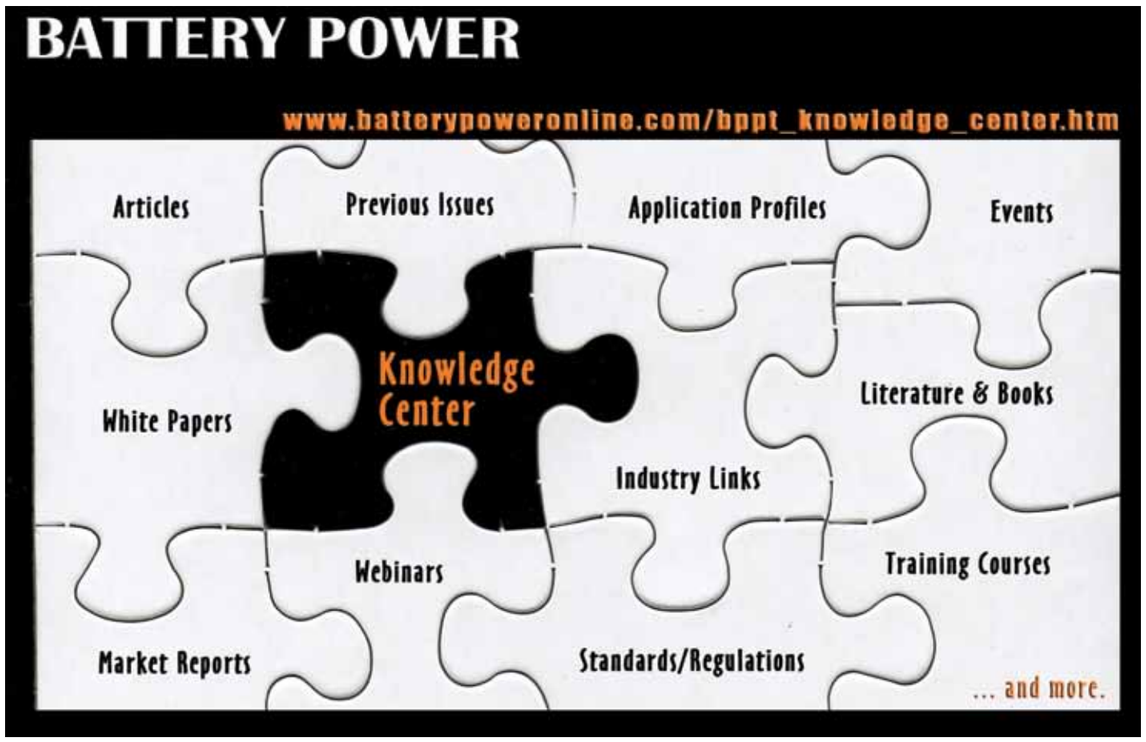
Cadex Electronics, Inc. has introduced the next generation of the Cadex C8000 advanced battery testing system. The Cadex C8000 delivers the versatility needed to optimize batteries at every stage of product life. Its wide-ranging capability is well suited for use during initial product design right through to managing batteries in service.

The C8000 features device simulation functions such as load capture and playback assist initial battery selection, as well as a variety of life cycle testing options that can be used to characterize the battery. Custom programming is available to create

specific routines to monitor quality and performance and standard service programs are used for simple and effective battery maintenance.

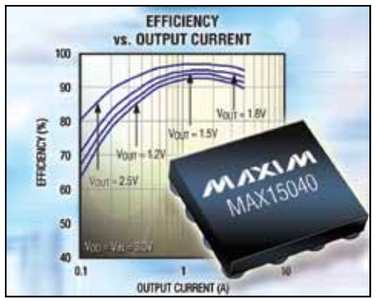
Additional highlights include control of thermal chambers to test the effects of thermal cycling on battery properties and parallel channel capability to double the power capability by combining two channels into one.

The C8000 demonstrates its versatility with multiple battery interface options, standard programs for lead-acid, nickel and lithium chemistries and standard or custom waveforms, all coupled with powerful BatteryLab PC software that allows advanced data capture and graphic analysis.



A 4 Amp Switching Regulator Simplifies Designs and Improves Reliability

Maxim Integrated Products has introduced the MAX15040, a low-voltage (2.4 V to 3.6 V), synchronous switching regulator in a 2 mm by 2 mm wafer-level package (WLP). This miniature step-down regulator integrates MOSFETs to simplify design, minimize EMI, improve reliability and save board space. The



MAX15040 operates from a fixed 1 MHz switching frequency to further reduce total solution size, as it allows all-ceramic-capacitor designs. Offering efficiencies up to 94 percent at full load current (4 A), this point-of-load regulator minimizes power loss in applications such as telecom, networking and server equipment.

Other features include an enable input and power-good indicator for power sequencing, adjustable soft-start for controlled turn on, and the ability to safely start up into a prebiased output.

The MAX15040 provides ±1 percent output-voltage accuracy over temperature and is fully specified over the -40°C to 85°C extended temperature range. Prices start at $2.17 (1,000-up, FOB USA).

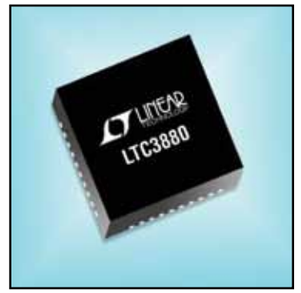
TI Releases Industry's First Qi Certified Development Tools and Chipset for Wireless Power

Texas Instruments, Inc. (TI) has introduced the industry's first Qi-certified wireless power development kit, which enables design engineers to speed the integration of wireless power technology in consumer electronics, such as digital cameras, smartphones, MP3 players and global positioning systems, along with infrastructure applications such as furniture and cars.

The bqTELSA development kit includes a single-channel transmitter, a direct-charge receiver and associated magnetics for applications requiring 5 watts of power or less. No additional software development is required, offering true plug-and-play functionality.

Dual Output Synchronous Step-Down DC/DC Controller with Digital Power System Management Via I2C/PMBus Interface and Onboard EEPROM

Linear Technology Corp. has announced the LTC3880/-1, a dual output high efficiency synchronous step-down DC/DC controller with I2C-based PMBus interface for digital power system management. The device combines improved analog switching regulator performance with precision mixed signal data conversion for ease of power system design and management, supported by the LTpowerPlay software development system with easy-to-use graphical user interface (GUI).



The LTC3880/-1 allows for digital programming and read back for real-time control and monitoring of critical point-of-load converter functions. Programmable control parameters include output voltage, margining and current limits, input and output supervisory limits, power-up sequencing and tracking, switching frequency and identification and traceability data. On-chip precision data converters and EEPROM allow for the capture and nonvolatile storage of regulator configuration settings and telemetry variables, including input and output voltages and currents, duty cycle, temperature and fault logging.

The LTC3880/-1 can regulate two independent outputs or be configured for a two phase single output. Up to six phases can be interleaved and paralleled for accurate sharing among multiple ICs, minimizing input and output filtering requirements for high current and/or multiple output applications. An integrated amplifier provides true differential remote output voltage sensing, enabling high accuracy regulation, independent of board IR voltage drops. Applications include high current ASIC, FPGA and processor supplies in telecom, datacom, computing and storage markets.

The LTC3880 features an onboard LDO for controller and gate drive power and the LTC3880-1 allows for an external bias voltage for highest efficiency. Both parts are available in a thermally enhanced 6 mm by 6 mm QFN-40 package. The extended temperature range grade is specified over a -40°C to 85°C operating junction temperature range. The industrial grade part is specified over a -40°C to 125°C operating junction temperature range. Pricing starts at $5.35 each in 1,000-piece quantities.

Summit's Programmable Multi-Output DC-DC Power Manager Simplifies Complex Power System Designs

Summit Microelectronics has announced a new programmable DC-DC power manager solution that brings added functional and feature integration with easy-to-use flexibility to a wide range of applications. Summit's SMB109 simplifies increasingly complex power design challenges by integrating multiple DC-DC outputs with digital power management/monitoring and non-volatile system configuration, reducing component count, cost, size and time-to-market. The SMB109 is well suited for powering advanced multi-rail digital chipsets in

a range of communications, computing and consumer applications such as notebook/netbook/tablet, server/storage, telecom/datacom and multimedia devices. Additionally the SMB109's high power-conversion efficiency, output voltage control and advanced power-down modes facilitate "green" and EnergyStar compliant design.

With a serial digital interface and on-board non-volatile memory, the SMB109 can be configured during development and re-programmed in-system by host software. The result is a flexible, digitally controlled power supply design that is easily customizable without tedious hardware design cycles or complex microcontroller-style GPIO-based control. The integration of advanced power control functions eliminates external components and cost, improves functionality and performance, and minimizes development time.

The SMB109 integrates eight outputs, three buck controllers, one LDO controller and four load switch controllers with a digital I2C interface. The current-mode buck controllers accept inputs from +4.5 V to +28 V and the output voltage can be digitally programmed from +0.5 V to +5.0 V (or higher with external resistor divider) in 10 mV steps with 1 percent regulation accuracy. Depending on the output MOSFET's used each buck output can support over 20 A continuous output current. Switching frequency is programmable from 300 kHz to 1,200 kHz to optimize size versus efficiency while the three buck outputs are interleaved by 120° to reduce current ripple and noise. Pulse skipping mode is supported (with fixed frequency PWM override) to optimize conversion efficiency during light load operation. The LDO controller controls an external N-channel MOSFET up to 5 A+ and also has a programmable output voltage of +0.5 V to +5.0 V.

Sub-Microamp Quiescent Current LDOs Extend Battery Life in Wireless Devices

Analog Devices, Inc. (ADI) has introduced four low-dropout regulators (LDOs) that address the size, power dissipation and power-supply-rejection requirements of wireless mobile devices. The ADP160, ADP161, ADP162 and ADP163 ultra-low-quiescent-current LDOs extend the battery life of portable devices by drawing only 560 nA (typical) at no load and 42 µA of quiescent current (typical) at full load. These LDOs provide 70 dB PSRR (power-supply-rejection ratio) at 60 Hz, which is more than twice that of competing LDOs at full load current. The ADP16x series LDOs are designed for applications such as power meter reader/data terminals, portable industrial, medical measurement devices and remotely located equipment operating from batteries or solar power.

The ADP160, ADP161, ADP162 and ADP163 LDOs provide up to 150 mA of output current and operate from 2.2 V to 5.5 V supplies. The ADP160 and ADP162 fixed-output voltage and ADP161 and ADP163 adjustable-output voltage regulators are available in TSOT (thin–small-outline transistor) packages, while the ADP160 and ADP162 are additionally available in WLCSP (wafer-level, chip-scale package) packages. The ADP160 and ADP161 also include an output switch to discharge the output load capacitor to zero volts when the device is turned off to ensure microcontrollers are in a known state for restart.

Fujitsu 6 MHz Buck-Boost DC/DC Converter Extends Mobile Device Battery Life with Minimum Footprint

Fujitsu Semiconductor America, Inc. (FSA) has released the Fujitsu MB39C326 power management IC (PMIC), a high-efficiency buck-boost DC/DC converter that operates at 6 MHz. Samples will be available in June 2011.

The Fujitsu MB39C326 PMIC is designed to power the radio frequency power amplifiers (RFPAs) in mobile handsets and other mobile products that use a single-cell Li-ion battery. The converter switches at 6 MHz compared with the 2 to 3 MHz or lower switching rates of conventional converters, enabling designers to use a smaller inductor. The result is a reduction of up to 50 percent in the overall board space of the power management circuits.

The buck-boost functionality of the Fujitsu MB39C326 PMIC prolongs battery life and efficiency. When a Li-ion battery is fully charged, it starts with a high operating voltage. As the Li-ion battery is discharged, its operating voltage declines to the point at which the battery cannot provide sufficient power to its host device even if some charge remains. The MB39C326 switches automatically between a buck operation (stepping down the voltage) when the battery is fully charged and a boost operation (stepping up the voltage) as the battery is discharged, which maximizes the battery's overall operating voltage and provides a stable power supply to the power amplifier. The result is a more consistent voltage level and a mobile device that can operate longer on a single charge.

The Fujitsu MB39C326 PMIC provides up to 800 mA of output current over an input voltage range of 3.1 V to 4.6 V. The device features a built-in, internal, field-effect transistor (FET), over-temperature protection and an input-under-voltage lockout. The MB39C326 is available in a 20-pin, 0.4 mm-ball-pitch, 2.15 mm by 1.94 mm WL-CSP (wafer level chip size) package.

TDI Introduces a New 2.7 kW, 12 V Liquid Cooled DC-DC Converter

TDI has developed LiquaCore (patent pending) power management technology, which allows the electronics package to remain sealed, while enabling efficient management of waste heat at very high power densities. The cooling liquid employed is either water or a mixture of water and ethylene glycol (antifreeze). By using standard power modules TDI Power can configure a complete high power solution.

As part of their power management technology, TDI Power has developed a 2.7 kW, 12 V liquid cooled DC/DC converter that boasts 93 percent efficiency. This replaces conventional alternators for more power at lower RPMs. It's modular and scalable for higher power needs, up to 100 kW. This unit is well suited for harsh vehicle applications, it also lends itself to high volume manufacturing, using common mechanical extrusions and mainstream components, resulting in lower costs.

Emerson Network Power Adds Higher Capacity, Power Distribution and Maintenance Bypass Cabinet to Liebert NX UPS Product Line

Emerson Network Power has released 160 kVA and 200 kVA ratings in its Liebert NX with Softscale double conversion uninterruptible power supply (UPS) platform, designed for midsize businesses seeking a backup power solution that grows incrementally without requiring infrastructure renovation.

Now spanning the range of 40 kVA to 200 kVA, the Liebert NX product line includes optional maintenance bypass/power distribution cabinets. A single maintenance bypass/distribution cabinet provides complete wrap-around bypass for a UPS system, and may also be used to provide input and output voltage transformation. The cabinets are available with panel board or sub-feed output distribution.

The Liebert NX UPS is available with front and rear access for easy integration into a row of racks, or front-only access for installation against a wall. The Liebert NX UPS may be located on a raised or solid floor, and provides maximum wiring flexibility by including provision for bottom or overhead cable entry.

Softscale technology is included in all Liebert NX UPS units from 40 to 200 kVA, allowing the UPS to be sized to current power requirements and easily scaled up to a larger capacity with a simple software key as power needs grow. System ratings are scalable from 40 to 80 kVA, from 80 to 120 kVA, or from 160 to 200 kVA. This feature offers IT managers an economical path on which to plan for data center growth without adding to the UPS footprint. For higher power applications or when system redundancy is desired, the Liebert NX power cores can be paralleled to provide up to 600 kVA of capacity with +1 redundancy.

15 Watt Chassis Mount Encapsulated AC/DC Power Supply

ConTech, a Division of Calex Mfg., has released the PC15 series of AC/DC switching power supplies. The PC15 series offers 15 watts of output power in an encapsulated case, making it well suited for ruggedized backplane applications. The optional Din-Rail mount and easily accessible terminal blocks give it the versatility to be used as a power solution in a large assortment of applications.

The PC15 series operates from a standard 85 to 265 VAC at 47 to 440 Hz. Single output models are available with outputs from 5 VDC to 48 VDC. Dual and triple output versions are also available. Protective features used in this series are output over-voltage protection and short circuit protection. The units are encapsulated with a thermally conductive potting compound in a plastic resin and fiberglass case that meets UL94V-0. The enclosed case has external terminal blocks for ease of connection and is chassis mountable. Adding optional accessory DIN-01 base plate easily converts the chassis mount case to a standard Din-Rail mount. The PC15 series is rated for 3,000 VAC isolation, is UL approved and is RoHS compliant. A PCB mount version of this series is available as the PK15 series. Pricing for the PC15 series is priced as low as $30.25/ea.

Zeon Announces New Anode and Cathode Binders for Li-Ion Batteries

Zeon Corp. has introduced its newest grades of anode and cathode binders for Li-Ion batteries. Zeon's anode binder, BM-480B, provides three key benefits as compared to conventional SBR binders, including lower resistance and improved cycling performance at temperatures below 0°C; and improved storage and cycling performance at temperatures to 60°C. For Li-Ion cell producers using polyvinylidene fluoride (PVDF) binder systems, Zeon's aqueous-based binders, including BM-480B and Zeon's aqueous cathode binders, provide safety benefits and reduce overall costs by elimination of NMP solvent handling and recovery systems. Additionally, Zeon's aqueous binders are used at lower loadings than PVDF, enabling higher density cells.

Maxwell Technologies Introduces Ultracapacitor-Based Backup Power Module for Uninterruptible Power Supply Systems

Maxwell Technologies, Inc. has introduced a 56-volt ultracapacitor module designed to address the short-term ride-through and bridge power requirements of uninterruptible power supply (UPS) systems for mission-critical installations such as data centers, hospitals, factories and telecommunication facilities.

Maxwell developed the UPS module in consultation with leading UPS system integrators to mitigate the effects of brief power disturbances on digital systems and sensitive medical and manufacturing equipment, and to provide bridge power to a generator or other long-term backup power source in the event of a complete power outage.

The new product is being installed in several beta sites and the company will begin accepting additional orders in March. Key features and benefits include maintenance-free operation and estimated 14-year life ensure low cost of ownership and 3U and 4U rack-mount form factors for easy integration into standard equipment racks.

Unlike batteries, which produce and store energy by means of a chemical reaction, Maxwell's BoostCap ultracapacitor products store energy in an electric field. This electrostatic energy storage mechanism enables ultracapacitors to charge and discharge in as little as fractions of a second, perform normally over a broad temperature range (-40°C to 65°C), operate reliably through one million or more charge/discharge cycles and resist shock, vibration and overcharging. Maxwell offers ultracapacitor cells ranging in capacitance from 5 to 3,000 farads and multi-cell modules ranging from 16 to 125 volts.

Frost Continued from Page 13

maintenance-free batteries an integral part of utilities.

Grid energy storage serves as a controllable demand-side management option that can also provide premium services. These premium services include power quality for sags or surges lasting less than 5 seconds, uninterruptible power supply backup for outages lasting approximately 10 minutes, and peak demand reduction to reduce electricity bills.

Grid energy storage can optimize the electricity grid and enable wind and solar power plants to become more economical. Utilities would be able to store electricity made from renewable sources or produced during off-peak times. Then, when demand for electricity peaks, utilities draw from the reserved charge. Renewable energy sources such as wind and solar are intermittent power generators that require supplemental peaking power plants to ensure seamless operation.

Grid stabilization is a key focus area for energy storage solutions. Today's electric power utilities utilize conventional battery technologies for grid load leveling and spinning reserve backup applications. For larger-scale peak shaving applications, compressed air, pumped hydro and thermal energy systems are generally viewed as viable options. Current lithium-ion batteries do not offer the power output and cost levels of compressed air and pumped hydro. Additionally, lithium-ion is not proven in the field at this time in development. Therefore, a majority of lithium-ion battery manufacturers are focused on grid stabilization, backup, load leveling functions.

Energy providers require an efficient process to store and release electric power on demand. Although not in use today, high-power, energy-dense lithium-ion batteries are considered a viable option for future grid energy storage solutions. The US market for utility-scale lithium-ion batteries is lucrative and expected to generate significant market opportunities.

Telecom/ Data Comm Backup: Factors that are likely to influence the lithium-ion battery market toward increased penetration and adoption include price, increased production to cater to the growing demand in the market and technology breakthroughs to improve specific parameters that are requisites for the telecom and data com market. As an emerging niche area, lithium-ion battery usage with UPS and DC power systems is penetrating slowly.

Lithium-ion batteries for telecommunication and data communication backup applications are considered a niche market. More than 84 percent of backup systems (uninterruptible power supplies (UPS) and DC power systems) utilized stationary lead acid battery technologies. Market penetration for lithium-ion is expected to be slow until 2014 to 2015. Longer life cycle, lower maintenance and its role as a cleaner alternative serve as the main driving forces in the market for lithium-ion based telecom/data com backup systems. Inherent characteristics such as high energy density, high rate of discharge capabilities and low self discharge make lithium-ion batteries ideal for this application segment.

Lead acid batteries have been used in telecom/data com backup for decades. Low cost, reliability, simple to operate, straightforward scalable features, easily accessible, established recycling infrastructure, battery manufacturers acts as user's partner (for sales, service, support, full network of solutions) are some of the key characteristics that have maintained lead acid battery usage for this application.

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Several alternative technologies such as fuel cells, ultracapacitors, flywheels and other electrochemical batteries are in the process of testing and evaluation stage for utilization in telecom/data comm backup applications. Although these technologies are not fully commercialized, they offer more energy density than lithium-ion chemistry. Hence these technologies are likely to hinder growth of lithium-ion battery market when these are commercialized.

Military/ Aerospace: Strong potential for lithium-ion battery penetration as more complex, robust equipment requires energy and power-dense battery technology.

High-power, energy-dense lithium-ion batteries have started penetrating many aerospace and defense applications. This chemistry is attracting focus for several reasons including

lightweight and high-energy characteristics, lower maintenance costs, and extended runtimes. Compared to other battery chemistries lithium-ion provides increased energy density, charge retention, and power without the need for scheduled cycling, prolonged priming or other costly maintenance practices. Lithium-ion offers a lower total cost of ownership for many aerospace and defense applications.

However, initial investment is still substantially high and customers in this application market remain sensitive to this additional cost. Currently a growing market area, lithium-ion battery usage with aerospace and defense applications is gaining momentum. The chemistry is now reaching mass implementation stage and is not considered an unsafe system. For aerospace in particular, lithium-ion is reaching completion of a 15 year mission test evaluation that has enabled this user group to fully understand key safety, performance and capabilities of lithium-ion in extreme conditions.

However, Department of Defense (DoD) contracts have a feast or famine nature, and for companies receiving one-off contracts on an irregular basis, surviving in a time of tightened financial lending is difficult. The assumption that the military/aerospace market is a safe haven in terms of product sales opportunities is not incorrect for those companies that have become established battery providers to the DoD.

Off-Grid: Off-grid power system market for lithium-ion batteries is in nascent stage. Power sources currently used in these products include lead acid batteries and fuel cells.

Off-grid power products are suitable in consumer, recreational, automotive, maritime and industrial applications. In the automotive sector, off-grid power systems (termed as auxiliary power units (APU)) are used for transportation, construction, or maintaining vital infrastructure. APUs provides commercial vehicles with a rugged and dependable off-grid power source. Battery APUs generally consists of two or four battery packs for short-haul and eight battery banks for long-hauls. Battery APUs is an emerging market and provides growth potential for large-format lithium-ion batteries.

Other applications classified as off-grid power applications include maritime power, remote location power, traffic regulation, security surveillance and emergency power generators. Off-grid power system market for lithium-ion batteries is in nascent stage. Power sources currently used in these products include lead acid batteries and fuel cells. Currently a nascent market area, lithium-ion battery usage with off-grid power systems is penetrating slowly.

Remote off-grid power sources must provide the following attributes:

- Silent operation, environmentally friendly
- High power density, automatic operation
- Limited or zero initialization time, convenient remote controlled ability, scalable for increased power requirements

Battery APUs is a lucrative market opportunity. This solution can be used for short and long-haul trucks, construction equipment, off-road transport (i.e. logging trucks) and buses. With increasing anti-idling legislation and increasing fuel costs, commercial trucks are increasingly dependent on batteries for overnight comfort (air conditioning/heat/accessory) loads. Impending environmental legislation will likely impact diesel/gas powered portable generators, providing market growth potential to replace units with battery-powered options. For several off-grid applications, reliability is a major concern as failure and/or downtime is exceedingly costly.

Key Trends

A lithium-ion battery is considered to be the power source for the future. These batteries offer efficient performance in consumer electronics and in industrial applications. The batteries gained strong potential for power tools market and is likely to be widely used in military, aerospace and defense applications as well. The inherent disadvantage of safety factor is the only major restraint that stops this chemistry to be used in all applications. Within two decades of its existence, lithium-ion batteries have quickly replaced other rechargeable batteries that were well established in the market. This chemistry has huge growth potential in industrial and automotive applications. All major battery manufacturers and vehicle makers are involved in the research and development activity of making lithium-ion battery suitable to power alternative vehicles. This is likely to be achieved during the next few years, which would increase the market potential of lithium-ion batteries to remarkable extent. High price per cell and severe competition are the two challenges that needs to be resolved during the forecast period for proportional revenue and units shipment growth in this market

Conclusion

The US has been cultivating battery innovation and advancement for years; however Asia still remains the central of the energy storage manufacturing process. This trend could shift as advanced lithium-ion batteries are beginning to enter the market. These batteries are key to the next-generation hybrid electric, plug-in hybrid electric, and battery-electric powered vehicles as well as grid energy storage, telecom backup and aerospace/defense applications. With the much needed US Federal government support in the form of loans, grants, and tax incentives for advanced battery research and manufacturing, the US region could witness a renaissance in global battery manufacturing. One key issue regarding offshore manufacturing compared to US manufacturing revolves around the national security of supply. This issue affects the aerospace/defense and grid energy storage application markets profoundly and could create market penetration delays for lithium-ion.

Contact Frost and Sullivan at www.frost.com.

Call2Recycle Posts Record Increase of Battery Recycling in 2010

Call2Recycle has announced a record-breaking 10.1 percent increase in its overall rechargeable battery collections in 2010. Through its network of more than 30,000 retail, municipal and business partners across the US and Canada, Call2Recycle collected more than 6.7 million pounds of rechargeable batteries during the year.

"The battery recycling landscape is changing, with the enactment of legislation in Canada and the consideration of new legislation in other areas," said Carl Smith, president and CEO of Call2Recycle. "That, coupled with the strength of our 2010 results and a heightened awareness among industries and the public of the importance of recycling the items we use, inspires confidence in our performance for 2011 and beyond."

Throughout North America, healthcare and public agencies saw a 106 and 32 percent increase in battery recycling respectively. Also in 2010, consumer battery recycling efforts through retailers and communities surged by 17 percent.

Johnson Controls Breaks Ground on Fully-Integrated Battery Recycling Facility

Johnson Controls, Inc. has broken ground on a fully-integrated battery recycling facility in Florence, S.C. The Florence Recycling Center, slated for completion during 2012 and to be operated by Johnson Controls' Power Solutions business, represents a capital investment of more than $150 million and will create an estimated 250 new jobs and approximately 1,000 indirect jobs in the area. The facility is the first facility of its kind to receive an air permit in the US in nearly 20 years.

New Ford Focus Electric to Offer Convenient Charging Station with Plenty of Consumer Benefits

The Ford Focus Electric offers customer-centered technology and a home charging station. Jointly developed with Leviton, a North American producer of electrical devices, the unit offers a variety of benefits for Focus Electric customers.

One of the main advantages of the charging station is the nonpermanent-style installation. The unit plugs into a 240-volt outlet instead of being hard-wired into the electrical breaker box. The nonpermanent-style design makes removal and replacement as simple as unplug and plug back in should the owner move.

Ford is working with Best Buy to sell the charging station and offer complete consultation and installation services through its Geek Squad subsidiary and third-party licensed electrical contractors. Based on current plans, the Focus Electric home charging station with standard installation is expected to retail for approximately $1,499, as much as 30 percent less than competitors' systems. The unit also will have a limited 10-year hardware warranty.

Electrification is an important piece of Ford's overall product sustainability strategy. Ford's aggressive strategy includes the launch of five new electrified vehicles in Europe and North America. In addition to Focus Electric, Ford introduced the Transit Connect Electric small commercial van in 2010. The company also will launch two next-generation lithium-ion battery hybrids and a plug-in hybrid in 2012. The range of electrified vehicles allows Ford to address a variety of consumer driving needs.

Intertek Certifies Chevy Volt Electric Vehicle Charging Technologies

Intertek has certified General Motors' Electric Vehicle Charging Station and Portable Charging Cordset to US and Canadian electrical product safety standards. Branded as the "Voltec," the electric charging station and portable charging cordset are supplied by Lear Corp. and will be available with the General Motors' 2011 Chevy Volt electric vehicle.

General Motors' Voltec charging station and portable charging cordset is an innovation in charging technologies for electric vehicle batteries. Similar to common household appliances, the charging station will be installed at a consumer's residence for at-home charging of the vehicle. The portable charging cordset, a stand alone accessory, is carried within the vehicle and allows the consumer to plug-in to any common household outlet for charging the vehicle while travelling.

LG Chem, Argonne National Laboratory Sign Licensing Deal to Make, Commercialize Advanced Battery Material

The US Department of Energy's (DOE) Argonne National Laboratory and LG Chem, Ltd. have reached a licensing agreement to make and use Argonne's patented cathode material technology in lithium-ion battery cells.

The technology is in the battery cell that is powering General Motors Company's Chevrolet Volt, the first mass-produced plug-in hybrid electric vehicle. The Volt has an EPA estimated range of 35 miles on a full charge.

The Argonne-developed technology offers the longest-lasting energy available in the smallest, lightest package: a 50 percent to 100 percent increase in energy storage capacity over conventional cathode material. Further, its unique lithium- and manganese-rich mixed-metal oxide combination extends the operating time between charges, increases the calendar life and improves the inherent safety of lithium-ion cells.

"We believe that Argonne's patented cathode material technology that helps increase the capacity of lithium-ion battery cells and LG Chem's safety-enhanced SRS (separator) technology are the keys to producing high-performance and safe batteries for the GM Volt," said Youngjoon Shin, Ph.D., research fellow, Battery R&D, LG Chem.

"The licensing agreement with LG Chem concretely illustrates the key role that DOE national laboratories like Argonne play in the manufacturing supply chain in the United States," said Eric Isaacs, Argonne director and president of UChicago Argonne, LLC, a wholly owned laboratory management subsidiary of the University of Chicago. "The development of this cathode material is the result of research performed by a multidisciplinary team of world-class scientists based at Argonne."

Argonne has developed and patented a sizable suite of Li-Ion

battery technologies with funding from DOE's Office of Energy Efficiency and Renewable Energy. Funding for the earlier stages of research and development of this technology was provided by DOE's Office of Science.

EnerSys DataSafe 16 V Battery Cabinets Granted OSHPD Certification

Recognized internationally for its solutions in stored energy for industrial applications, EnerSys has earned a special seismic certification by the Office of Statewide Health Planning and Development (OSHPD) in California, for its DataSafe 16 V battery cabinets.

"There is a growing demand for OSHPD compliance. The OSHPD certification represents the highest quality of equipment that is tested and deemed trustworthy by facilities engineering experts after a series of rigorous tests," said Steve Vechy, senior director engineering and quality assurance, EnerSys Americas.

Due to the inclination for seismic activity in California, OSHPD's Facilities Development Division (FDD) has developed stringent building standards, in compliance with the California Building Code, which hospitals in California must comply with to ensure the facility's seismic safety. The FDD is the governing body that regulates the design and construction of healthcare facilities for public safety in California.

The cabinets were approved in the first round of a rigorous OSHPD testing process at the ISO/TEC 17025-accredited Environmental Testing Lab. To meet certification, OSHPD requires multiple units to be tested on a seismic shake table, which is used to test the resistance of structures to seismic shaking and ground motion. To simulate an earthquake, the table shakes the units violently from side-to-side and front-to-back simultaneously and is capable of achieving the Required Response Spectra (RRS).

Saft Receives Li-Ion Battery Order from Boeing for Inmarsat Satellites

Saft is preparing to fill its next order for lithium-ion (Li-ion) space batteries as part of a five-year long term agreement signed with Boeing Space and Intelligence Systems in 2009. Under the multi-million dollar contract, Saft will deliver 12 battery packs of high-energy Li-Ion batteries for Boeing's 702HP satellites being built for the Inmarsat-5 series.

The Saft batteries, with VES140S cells, will power three new Ka-band satellites, adding to Inmarsat's current fleet of 11 GEO satellites. These satellites provide a wide range of voice and data services through an established global network of distributors and service providers. Each Inmarsat-5 satellite will carry 89 Ka-band beams that will operate in geosynchronous orbit with flexible global coverage.

Saft's batteries will offer 15 kW of onboard power for the satellites' critical systems in a low-weight package. With up to 18 years of battery life, the rechargeable Li-Ion batteries will ensure continuous, reliable operation of the satellites at times when the satellite and its solar panels are in eclipse.

Index of Advertisers

Calendar of Events

March

14-17- **28th International Battery Seminar & Exhibit**, Fort Lauderdale, Fla.

22-23 - **TREM11**, Washington, D.C.

May

1-4 - **BCI's 123rd Convention and Power Mart Trade Fair**, Miami, Fla.

12-15 - **Battery Alliance**, Bonita Springs, Fla.

16-18 - **BATTCON**, Orlando, Fla.

June

6-10 - **Advanced Automotive Battery Conference Europe**, Mainz, Germany

7-10 - **LABT'2011: 8th International Conference on Lead-Acid Batteries**, Albena, Bulgaria

September

20-21 - **Battery Power 2011**, Nashville, Tenn.

October

9-13- **INTELEC 2011**, Amsterdam, The Netherlands

Send Calendar of Event listings to Shannon Given at shannong@infowebcom.com.

New Nano-Engineered Batteries Exhibit Remarkable Power Density, Charging More Than 40 Times Faster Than Today's Lithium-Ion Batteries

Researchers at Rensselaer Polytechnic Institute have developed an entirely new type of nanomaterial that could enable the next generation of high-power rechargeable lithium-ion (Li-Ion) batteries for electric automobiles, laptop computers, mobile phones and other devices. The material is called a "nanoscoop" because it resembles a cone with a scoop of ice cream on top. Nanoscoops can withstand extremely high rates of charge and discharge that would cause today's Li-Ion batteries to rapidly deteriorate and fail.

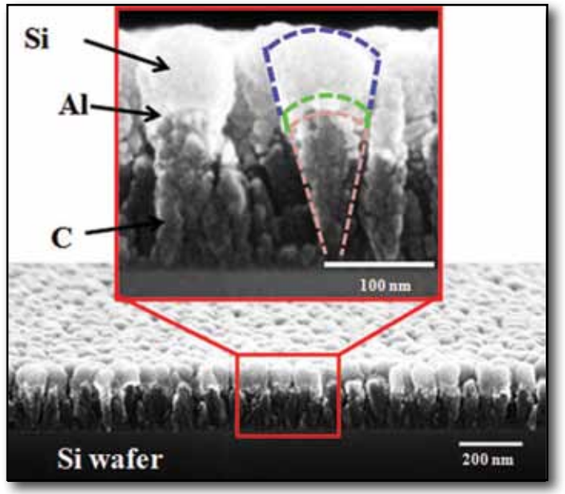
The Rensselaer research team, led by Professor Nikhil Koratkar, demonstrated how a nanoscoop electrode could be charged and discharged at a rate 40 to 60 times faster than conventional battery anodes, while maintaining a comparable energy density. This performance, which was achieved more than 100 continuous charge/discharge cycles, has the team confident that their new technology holds significant potential for the design and realization of high-power, high-capacity Li-ion rechargeable batteries.

"Charging my laptop or cell phone in a few minutes, rather than an hour, sounds pretty good to me," said Koratkar, a professor in the Department of Mechanical, Aerospace and Nuclear Engineering at Rensselaer. "By using our nanoscoops as the anode architecture for Li-Ion rechargeable batteries, this is a very real prospect. Moreover, this technology could potentially be ramped up to suit the demanding needs of batteries for electric automobiles."

Batteries for all-electric vehicles must deliver high power densities in addition to high energy densities. These vehicles today use supercapacitors to perform power-intensive functions, such as starting the vehicle and rapid acceleration, in conjunction with conventional batteries that deliver high energy density for normal cruise driving and other operations. The invention of nanoscoops may enable these two separate systems to be combined into a single, more efficient battery unit.

The anode structure of a Li-Ion battery physically grows and shrinks as the battery charges or discharges. When charging, the addition of Li ions increases the volume of the anode, while discharging has the opposite effect. These volume changes result in a buildup of stress in the anode. Too great a stress that builds up too quickly, as in the case of a battery charging or discharging at high speeds, can cause the battery to fail prematurely. This is why most batteries in today's portable electronic devices like cell phones and laptops charge very slowly; the slow charge rate is intentional and designed to protect the battery from stress-induced damage.

The Rensselaer team's nanoscoop, however, was engineered to withstand this buildup of stress. Made from a carbon (C) nanorod base topped with a thin layer of nanoscale aluminum (Al) and a "scoop" of nanoscale silicon (Si), the structures are flexible and able to quickly accept and discharge Li-Ions at extremely fast rates without sustaining significant damage. The segmented structure of the nanoscoop allows the strain to be gradually transferred from the C base to the Al layer, and finally to the Si scoop. This natural strain gradation provides for a less abrupt transition in stress across the material interfaces, leading to improved structural integrity of the electrode.



Researchers at Rensselaer Polytechnic Institute developed an entirely new type of nanomaterial called a nanoscoop because it resembles a cone with a scoop of ice cream on top, is shown in the above scanning electron microscope image. Nanoscoops can withstand extremely high rates of charge and discharge that would cause today's Li-Ion batteries to rapidly deteriorate and fail.

"Due to their nanoscale size, our nanoscoops can soak and release Li at high rates far more effectively than the macroscale anodes used in today's Li-Ion batteries," Koatkar said. "This means our nanoscoop may be the solution to a critical problem facing auto companies and other battery manufacturers, how can you increase the power density of a battery while still keeping the energy density high?"

A limitation of the nanoscoop architecture is the relatively low total mass of the electrode, Koratkar said. To solve this, the team's next steps are to try growing longer scoops with greater mass, or develop a method for stacking layers of nanoscoops on top of each other. Another possibility the team is exploring includes growing the nanoscoops on large flexible substrates that can be rolled or shaped to fit along the contours or chassis of the automobile.

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