BATTERY POWER

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

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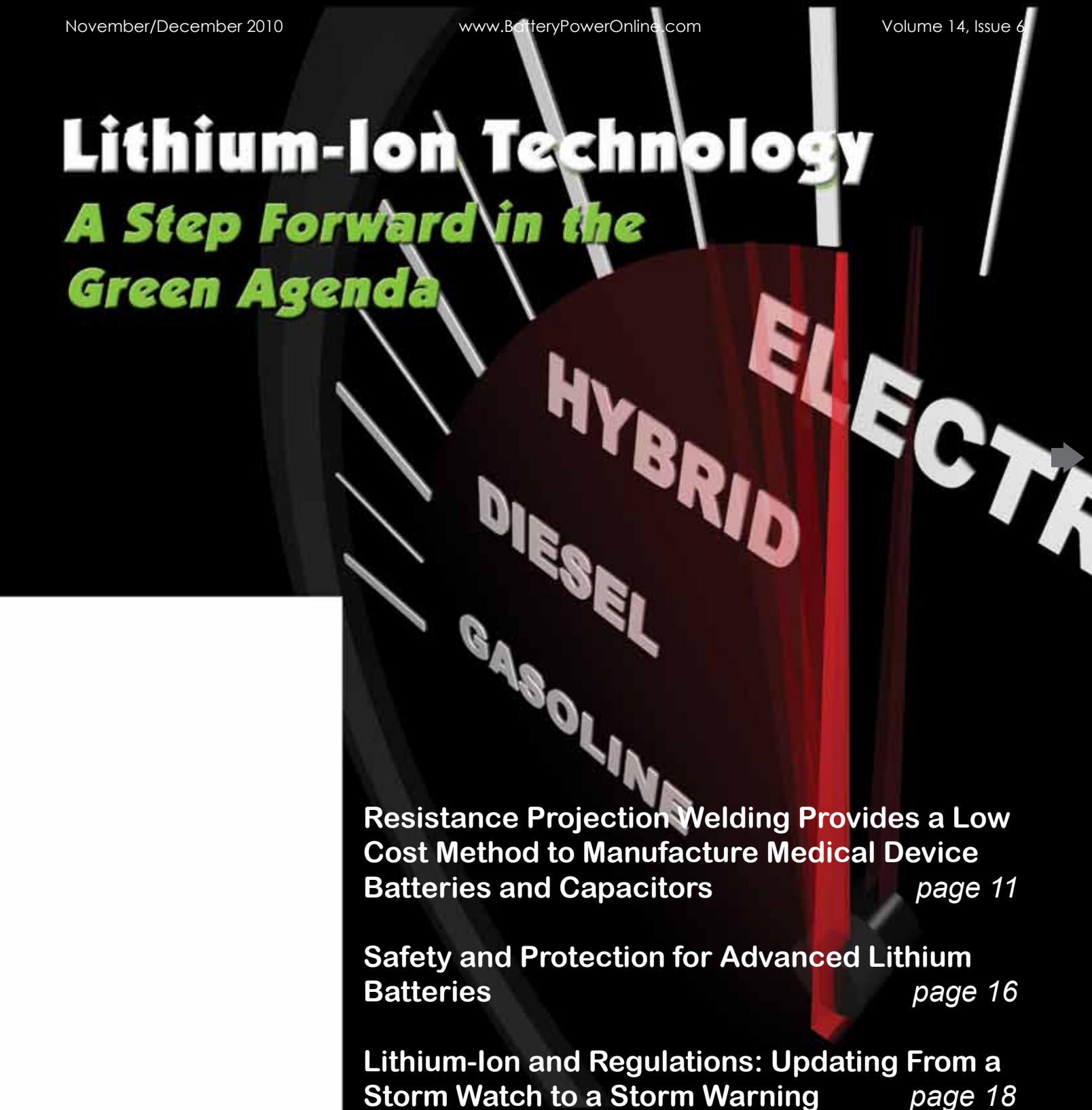
Lithium-Ion Technology

A Step Forward in the Green Agenda



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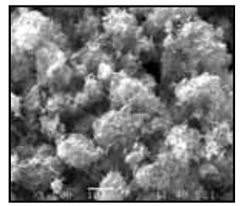

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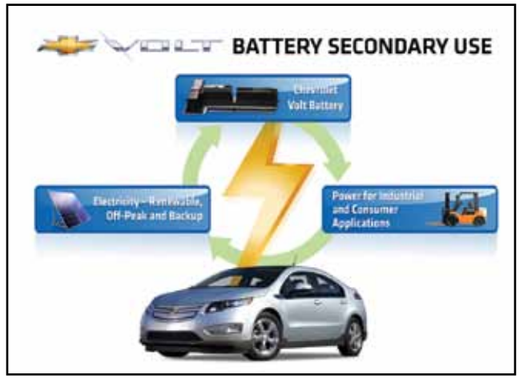
Chevrolet Volt Batteries Could Enable Renewable Energy Solutions

General Motors and ABB Group will work together to develop pilot projects for re-using the batteries from the Chevrolet Volt electric vehicle, examining whether the batteries may be a source for renewable energy that could improve the effectiveness of wind and solar power generation.



The two companies are collaborating to determine how the Volt's 16 kWh lithium-ion batteries can be used to provide stationary electric grid storage systems once the batteries have fulfilled their usefulness in customers' vehicles. The ultimate goal is to provide cost-effective, innovative solutions that will improve the efficiency of the country's electrical grid.

"The Volt's battery will have significant capacity to store electrical energy, even after its automotive life," said Micky Bly, GM executive director of Electrical Systems, Hybrids, Electric Vehicles and Batteries. "That's why we're joining forces with ABB to find ways to enable the Volt batteries to provide environmental benefits that stretch far beyond the highway."

"Future smart grids will incorporate a larger proportion of renewable energy sources and will need to supply a vast e-mobility infrastructure, both of which require a wide range of energy storage solutions," said Bazmi Husain, head of ABB's smart grids initiative. "We are excited to explore the possibility of employing electric car batteries in a second use that could help build needed storage capacity and provide far-reaching economic and environmental benefits."

Quallion Unveils New Anti-Idling Battery Technology And Advanced High Efficiency HVAC System for Commercial and Military Truck Applications

Under a grant from the Department of Energy, Quallion LLC has developed an innovative battery powered Anti-Idling HVAC solution designed for Class 6-8 trucks. This system offers up to 10 hours of uninterrupted battery powered cooling. The DOE and Quallion have developed this new technology to meet OEM specification requirements and have installed the battery in a Class 8 truck for preliminary field testing with plans to obtain data for future commercialization.

"This technology will revolutionize how we look at cooling systems, whether in a commercial truck, military vehicle platforms, or even forward base operations. By designing an ultra-efficient HVAC system, Quallion's battery solution is 25 percent of the weight of an equivalent lead acid system with a standard HVAC used in trucks today. The resulting fuel savings will greatly reduce fleet operating costs as well as drastically reduce greenhouse gas emissions," said Paul Beach, president of Quallion LLC.

Heavy-duty truck idling contributes a large portion of NOx emissions and particulate matter released into the atmosphere. According to the Environmental Protection Agency, truck idling burns over 3 billion gallons of diesel annually resulting in emissions of 11 million tons of CO_2, 180,000 tons of NOx and 5,000 tons of particulates. These are some of the hardest emissions to clean up due to the high cost of retrofitting the large number of trucks on the road today with more advanced diesel engines or pollution controls. By contrast, Quallion's solution can be installed in vehicles at service stations at a relatively low cost.

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MIPI Alliance Forms Battery Interface Working Group For Mobile Devices

MIPI Alliance has announced the formation of a new Battery Interface Working Group, targeting such issues as counterfeit batteries, consumer safety and power management. Comprised of companies spanning the mobile ecosystem, the working group will develop new specifications for the mobile battery interface system.

"Today, many mobile phones use low cost, non-smart batteries, which can be easily counterfeited," said Markus Littow, Chair of the MIPI Alliance Battery Interface Working Group and principal system design engineer with ST-Ericsson. "Counterfeit batteries cause consumer safety problems such as exploding or burning battery packs. Smart batteries will significantly reduce the risk of counterfeit batteries. Our working group will develop specifications to enable low cost smart batteries."

Smart battery technology offers many benefits. A special integrated circuit in the battery pack monitors the battery and reports information through the interface to the bus. Some examples of this information include but are not limited to: battery type, model number, manufacturer, characteristics, discharge rate, predicted remaining capacity, an almost-discharged alarm, temperature and voltage to provide safe fast charging.

However, most mobile manufacturers use a proprietary battery interface system forcing mobile component and battery pack manufacturers to support numerous interfaces in parallel, and often making the technology cost-prohibitive for mobile devices. By offering a battery interface specification, the Battery Interface Working Group hopes to ease design and manufacturing costs for smart batteries.

"The Battery Interface Working Group is tackling a very important issue, to both manufacturers and consumers," said Joel Huloux, chairman of the Board for MIPI Alliance. "Our organization strives to bring leading edge technology to the entire mobile device ecosystem. We believe the resulting specifications will spur adoption of smart battery technology."

The working group has framed its efforts to address the hundreds of variations in current battery cell chemistry and capacity. As a result, it will only specify the pull-down resistor range and measurement accuracy. Resistor value assignment for capacity and chemistry will be left to the mobile manufacturers. Also, the group will only address the electrical portion of the battery system, not the mechanical or battery form factors.

ActaCell and AVL to Design Lithium-Ion Battery Technology for Medium and Heavy-Duty Truck Market

ActaCell has engaged AVL to test ActaCell's lithium-ion battery technology in a number of independent, simulated settings to determine viability and efficiency for commercialization purposes.

Based on positive test results, the two companies have identified the power or strong hybrid electric vehicle (HEV) market, primarily comprised of medium and heavy-duty trucks, as the initial best fit for ActaCell's technology. The collaboration included developing a specific automotive grade, large format lithium-ion cell and module design to accommodate ActaCell's battery technology. Next steps include pilot-scale manufacturing and demonstration vehicle testing of the cell and module with select medium and heavy-duty truck companies.

ActaCell's lithium-ion battery technology is designed into thin pouch cells. Twelve cells are incorporated together to create a module. Eight modules are then packaged together to make a complete vehicle pack.

Ford Accelerates Electric Vehicle Battery Testing With Wireless Monitoring Systems

Ford Motor Company is leveraging the Internet and wireless technology to accelerate testing and refinement of the advanced lithium-ion battery systems that will power its upcoming plug-in hybrid and electric vehicles.

Ford's progress is enabled by two monitoring methods that allow engineers to collect real-time performance data from batteries in the lab and on vehicles in the field via a secure Internet server, and wirelessly update system software to improve capability and durability. These proprietary methods have significantly reduced test-fleet downtime and allowed Ford to more than double its battery lab-testing capability.

"Remote monitoring allows us to access real-time data and make continuous improvements very quickly," said Sherif Marakby, Ford director, Electrification Program and Engineering. "This degree of efficiency would have been unthinkable a few years ago and will help Ford bring more fuel-efficient, low-emission vehicles to market more quickly than ever before."

Ford's future hybrid and electric vehicles will use new lithium-ion battery systems that offer about twice the energy content of the nickel-metal-hydride systems used today, and take up less space inside the vehicle. Although lithium-ion batteries are widely used in the consumer electronics industry, the larger systems to be used in vehicles are designed to manage greater electrical loads under harsher conditions. Only through rigorous testing can the new systems be properly calibrated.

"The data we've collected have helped us understand how lithium-ion battery cells behave under various temperatures and states of charge," said Jas Dhillon, global electric vehicle fleet manager. "And the monitoring system allows us to make software updates to the fleet vehicles while they recharge. What used to be logistically complicated and time consuming can be accomplished now with a click of a mouse."

The North American Electric Vehicle Charging Industry to Reach $3.09 Billion by 2017

Verify Markets has released a market research report on the North American Electric Vehicle (EV) charging industry. The market, which is limited to level two and three chargers,

is expected to grow rapidly over the next five to seven years, reaching $3.09 billion by 2017.

The key factors that are driving the sale of EVs, and in consequence EV charging equipment, are the low costs to operate and maintain an electric vehicle, the desire for countries to be energy dependent and more green, and advances in technology. This includes better performing batteries and improved charger to grid/vehicle to charger communications, which make this industry possible.

The market is expected to reach unit shipments of 2.8 million by 2017, with over 85 percent of unit sales comprised of residential and multi-unit housing chargers. The level three charging industry, which will follow right behind the level two infrastructure, is expected to have more than 10,000 unit shipments by 2017 and revenues of more than $250 million on unit installations alone.

Competition in the industry will pick up drastically over the next two to three years when several major players, including ABB, General Electric, Eaton and Leviton, are expected to have some type of product in the market. Greater competition will increase the downward price pressure of EV chargers. This will likely decrease unit price by 50 percent in three to five years.

Epyon Introduces First Electric Vehicle AC/DC Combo Charge Post

Epyon, a European provider in intelligent charging solutions for electric vehicles, has announced the Terra Combo Charge Post, a fast charging post that supports both AC and DC connection standards. The post is the first in the industry that allows vehicles with different charging standards to be charged at the same post simultaneously, making this station cost-effective for utility providers, parking lots, local municipalities and gas stations.

"We believe in choice and want to offer a solution for both AC- and DC- powered electric vehicles," said Hans Streng, CEO of Epyon. "We don't want our customers to choose which standard to support. With the Terra Combo Charge Post, users will be able to charge most types of electric vehicles in 15 to 30 minutes."

The Terra Combo Charge Post has a user-friendly interface and will support a DC CHAdeMO-compliant connection up to 50 kW. The AC connection can be delivered according to the available standards in Europe: Mennekes, SCAME or J1772.

This combination of AC and DC will allow compatibility with all electric vehicles entering the market starting December 2010.

SwRI to Receive $1.2 Million Contract from Lawrence Berkeley National Laboratory for Battery Research

Southwest Research Institute has been selected by the Lawrence Berkeley National Laboratory to receive an award of $1.2 million to develop advanced anode materials for lithium-ion batteries. The award is one of several selected under LBNL's Batteries for Advanced Transportation Technologies (BATT) Program. The BATT Program is the fundamental research program supported by the US Department of Energy's Office of Vehicle Technologies and managed by LBNL for developing high-performance, rechargeable batteries for electric vehicles and hybrid-electric vehicles.

Institute scientist Dr. Kwai Chan, staff scientist Dr. Michael Miller and research engineer Dr. Wuwei Liang from SwRI's Materials Engineering Department are the team for the project, "Synthesis and Characterization of Silicon Clathrates for Anode Applications in Lithium-Ion Batteries." The project is scheduled to begin in January 2011 and is expected to be completed by December 2014.

"The objective of this project is to investigate how silicon clathrates can be used to improve the performance of lithium batteries," said Chan, who will serve as project manager for the four-year effort. "The primary application for the technology is electric, hybrid electric and plug-in hybrid electric automobiles." SwRI has been addressing advanced battery technologies through its internally funded research program.

Currently, most lithium-ion batteries have a 10-year life expectancy and a range of 10 miles between charges. A goal of the DOE and stakeholders is to quadruple the range and double the energy density of these batteries within the next four years while extending the battery life to greater than 10 years.

Silicon clathrate is a form of silicon with a cage structure that researchers believe can be used to store lithium at the battery anode. "The clathrate's soccer-ball-like structure would trap the lithium ions in a compact space," Miller added, "thereby providing a higher energy density and longer battery life."

Better Place, Sheraton Waikiki and Hawaiian Electric Partner on EV Charge Network in Hawaii

Better Place has announced the start of its initial deployment of EV infrastructure in Hawaii, with the launch of a project to incorporate its electric-vehicle infrastructure in Honolulu, in partnership with Kyo-ya Hotels & Resorts' Sheraton Waikiki Resort and Hawaiian Electric Company. The project will start with a small number of charge spots in Waikiki and around Oahu and includes seven electric vehicles. Better Place will manage the charging of the vehicles via a network operations center located in Palo Alto, Calif.

Better Place's initial charging stations will be based at partner Kyo-ya Hotel & Resorts' Sheraton Waikiki Resort where two electric vehicles will be used as fleet vehicles and guest shuttles. Other charging stations will be at three Hawaiian Electric sites. Hawaiian Electric has been collaborating with Better Place on the infrastructure and energy needs to power the public charging spots with renewable energy and this program will further advance that collaboration. The Hawaii Center for Advanced Transportation Technologies, which will provide the facilities for maintenance, will also have charge infrastructure onsite.

The deployment of the infrastructure is expected to begin in early 2011, with the focus of the project on measuring vehicle performance, battery-charging metrics, the impact on the electrical grid, driver behavior and the software systems that manage the charging network.

Lithium-Ion Technology: A Step Forward in the Green Agenda

Anu Cherian, Senior Industry Analyst,
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The automotive sector grabbed all the attention in 2009 with the release of several concept vehicles. This was most definitely a tricky diversion from the overwhelming grim economy. Consumers were so used to fulfilling their desires for the latest cars with easy loans in 2008. They had to put all their desires on the back burner in 2009 and gain a grip on the economy and the ensuing rigid market scenario. Nevertheless, persistent automakers continued to whet the appetites of consumers by making big promises of fuel economy and new battery technology, combined with electric or hybrid electric motors. In addition, they showcased sleek designs and defiant goals to consumers at the renowned auto shows in 2010. These strategies have placed the consumer on edge, awaiting their turn for a personal financial breakthrough to make their first investments.

The real driver is the lithium inside of the battery. Some of its nascent steps in advancing to large-scale production have been highlighted with A123 Systems grand opening of its new production facility.

The Lithium Interest

Lithium ion manufacturers that have a head start in the automotive industry are A123 systems, Magna, GS Yuasa, Acta cell, Boston Power, CFX Battery, Electrovaya, Mobius Power and Seeo, among others. There are several others that are intensely pursuing the automotive market. Once accepted, the volumes and economies of scale that can be achieved in the automotive sector are vast. In addition, it is the market that has sufficient leverage to be a trend setter in increasing acceptance of the technology.

The Head Start of A123 Systems in North America

A123 Systems is all set for the grand opening of the largest lithium-ion battery manufacturing plant in North America based on available data. The new plant in Livonia, Mich. is expected to expand A123's manufacturing capabilities by up to 600 MWh per year when fully operational, contributing to the company's plan to expand global final cell assembly capacity to more than 760 MWh hours annually by the end of 2011.

The opening of the Livonia factory comes just over one year after A123 was awarded a $249 million grant from the US Department of Energy (DOE) as part of the American Recovery

and Reinvestment Act to help the company execute its strategy to ramp up US manufacturing capabilities to meet increasing, market-driven demand for its innovative technologies.

The most significant benefit to switching to lithium-ion batteries is to improve the energy density by 150 percent, which would enhance battery system performance. The automotive lithium-ion battery market touched the $53.2 million mark in 2010, accounting for all the prototypes in use as beta testers for concept cars. Some of the other government funds provided to manufacturers are listed below.

- Johnson Controls ¬ Saft: $ 299.2
- KD ABG MI, LLC (Dow Kokam): $161.0
- Compact Power, Inc.: $151.4
- EnerDel, Inc.: $118.5
- General Motors Corp.: $105.9
- Exide Technologies with Axion Power Technologies: $34.3
- East Penn Manufacturing Co.: $32.5

In Pursuit of the Near-Term Market

The high-end performance car market is expected to provide the needed impetus to propel the market from a concept stage to production. Manufacturers such as Porsche, Ferrari and BMW hold a record to bring a concept to fruition and full production. This article further identifies the potential in the latest concept cars that can significantly propel the European and North American markets to transition to a lithium energy provider.

The Porsche 918 Spyder Concept

The heart of this green machine is a 500 horsepower V8 engine; electric motor powered with a lithium-ion battery attaining 218 horsepower and hits the road with the seven speed PDX gear box. The car is expected to operate in four modes.

- E-Drive which is meant for running on electricity only with an expected range of 16 miles
- Hybrid mode uses gas and electricity depending on the conditions
- Sport Hybrid mode also uses the gas electric mode but places the vehicle in a more advantageous position for performance over fuel efficiency
- Race Hybrid mode switches the car to complete top performance characteristics

The greatest advantage with Porsche is their history of always having brought a concept car into production, along with their aggressive drive to enter into the green race.

Not much has been revealed about the heart of the technology that decides between making and breaking this dream which is the proposed lithium battery. However, as with the Germans and their quest for the very best, no stone will be left unturned to make this miracle hit the road.

The Ferrari 599 HY-KERS Concept

In this vehicle, the electric motor runs alongside a 6.0 liter V12 engine reaching a top speed in 10.4 seconds. Its pertinent green benefits are carbon-dioxide reduction by 35 percent, regenerative use of braking power to recharge batteries and an electric motor rated at 100 horsepower. The long-term goal is to use this platform and create many such green options that can be incorporated into future designs of cars.

While performance car manufacturers are increasingly faced with new standards for fuel efficiency, the launch of the kinetic energy recovery systems (KERS) in the Ferrari 599 establishes Ferrari's capability to adapt to new regulations. Although much is not revealed about the lithium battery proposed to be used, its position below the floor plan of the car right inside the underbody is expected to decrease the center of gravity, thereby increasing stability. However, it is known that the lithium battery is expected to store up to 3 kw of electric energy.

BMW – Very Close on Heels

The ultimate driving experience is witnessing a gear change as BMW has seriously placed strategies to stay ahead in the race.

To rescue an industry that has been blamed extensively for the oil drain and inefficient use of natural resources, it is essential that the approach begin from the more affluent high-end customer to slowly percolate and gain ground in changing the entire dynamic of the affordable consumer market.

Its key focus has been on aspects that intrinsically decrease fuel efficiency such as start and stop, idling, as well as recovering braking energy. Although each car manufacturer targets the very same areas that need to be changed, each takes a new technology to deal with the problem. Some of the technologies that have suited regenerative braking are ultracapacitors, fuel cells and lithium-ion batteries. In the meantime, there is a possibility of using Magna as its lithium vendor for the near term needs of its green car design.

Other techniques used by BMW to increase fuel efficiency are high precision direct injection, twin turbo charging, and aerodynamic flaps behind the signature twin kidney grille. BMW's long-term goal is to explore the use of hydrogen technology, despite the current lack of necessary infrastructure to sustain its growth.

The battery design for each of the aforementioned performance car manufacturers is expected to be unique, as well as superior in design.

Conclusion

Everyone wants to go green, but right now the technology is focused on upper-end markets due to the cost. As these technologies mature, there is a possibility that they can reach various market segments. Meanwhile, it is interesting to watch how the energy storage sector targeting lithium ion integrates itself neatly into the automotive space with additional build ups to lithium aftermarket use and lithium recycling. The direction looks extremely positive, and the independent competitive approaches to parallel opportunities are important to build confidence in the use of lithium ion for hybrid electric vehicle systems.

Contact Frost & Sullivan at www.Frost.com.

Resistance Projection Welding Provides a Low Cost Method to Manufacture Medical Device Batteries and Capacitors

Charles Wood, Principal Engineer
techMatrix, LLC

Over the last decade there has been a significant increase in the quantity of medical devices employing leading edge battery and capacitor technologies to provide a safe and reliable energy source. Although laser welding is often used during manufacture of these components, a maturing device market and rising health insurance premiums are putting pressure on manufacturers to lower their component costs.

The use of small scale resistance projection welding may provide a cost effective alternative to manufacture battery and capacitor cover assemblies. This article will review the various resistance projection weld methods and the benefits they provide. The projection weld technique will then be applied to joining a titanium ball to a battery cover's fill port. Finally, a preliminary weld schedule will be developed and analyzed to understand the critical process parameters.

Resistance Projection Welding

Resistance projection welding is an extension to traditional resistance spot welding. The difference is the parts being joined have features that concentrate the weld energy and pressure to specific interfacial locations. In general, there are three basic projection weld joint configurations:

1. Formed or machined spherical or elongated bosses
2. Mismatched geometrical surfaces
3. Annular features.

Each configuration can be applied to overcome resistance spot weld problems, material issues or to increase joint consistency and reliability. Resistance projection welding provides a high current density at the part interface. The result is fast and focused heating, and a robust weld joint that is tolerant to variations in feature size, surface finish and material properties.

Resistance Projection Weld Advantages

Designing parts with projections offers many manufacturing advantages and can often make parts that are difficult to resistance weld much more consistent.

One challenge in resistance welding is joining parts that have an unequal thermal mass because one part is considerably thicker than the other. Using a projection feature helps focus the heat generated at the interfacial surfaces and minimizes bulk heating of the parts themselves. Bulk heating is the unwanted

heating of the part material away from the weld joint and causes a significant heat imbalance when one part is much larger than the other.

A second challenge is resistance welding parts that have low electrical resistivity. Resistance welding relies on Joule heating to heat the material to either its melting temperature for fusion welding or approximately 75 percent of its melting temperature for solid-state welding. Materials that have low electrical resistance like copper, aluminum or silver alloys can be reliably projection welded because the projection greatly increases the current density and confines the current flow to a defined location. Since material resistance increases with temperature, the localized heat increases the Joule heating efficiency for conductive materials.

Besides addressing common resistance weld material challenges, projection welding allows multiple weld nuggets to form simultaneously. One weld cycle, typically a fraction of second, results in a completed weld. Short cycle times and relatively inexpensive equipment are important manufacturing advantages compared to other joining technologies like laser welding.

Low tolerance part features combined with the ease of assembling parts that naturally self-center are other important cost reduction drivers associated with projection welding.

Battery and Capacitor Weld Covers

Medical device batteries and capacitors that rely on wet electrochemical cells must be hermetically sealed. The battery and/or capacitor are key electrical components for defibrillators, pacemakers, spinal cord stimulators and pumps to treat serious medical conditions. These devices are usually surgically implanted in the patient and therefore must not leak electrolyte onto the electrical circuit. A reliable hermetic seal is critical in preventing this failure mechanism.

For example, a generic 'D' shaped battery is shown in Figure 1. Medical batteries and capacitors are usually constructed from titanium due to its low weight and corrosion resistance. This article focuses on using resistance projection welds to secure the ferrule and fill port ball to the battery cover. These two joints have traditionally been made using Nd-Yag laser welds, but this can be a time consuming process that requires tightly toleranced components and expensive equipment when compared to resistance welding.

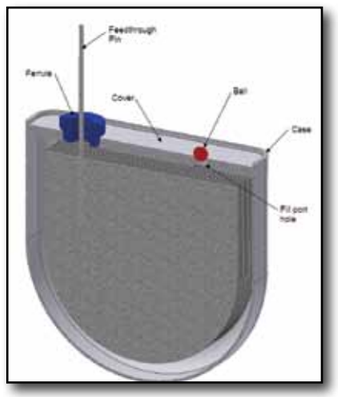


Figure 1. Generic medical device battery cross-section showing projection weld candidates: Ferrule (blue) and Ball (red)

The ferrule to cover joint and ball to fill port hole joint both rely on mismatched geometric surface projections to form a hermetic joint. In either situation, a single weld cycle, consisting of two pulses of energy, form the joint. The entire weld is completed in less than 250 ms, providing extremely short cycle times.

Ball to Fill Port Hole Weld

To learn more about small scale projection welding and its process parameters, the ball to fill port hole joint was investigated. The grade 2 titanium cover is 0.034 inches thick and the fill port through hole diameter is 0.043 ± 0.001 inches. The class 100, grade 5 titanium ball measures 3/64 inches in diameter and is placed over the hole. An opposed electrode resistance weld configuration is used.

Since the interface resistance changes rapidly during projection welding, power feedback was chosen to control weld energy. We also used a dual pulse weld schedule with the first pulse set to breakdown the oxide layer on the titanium and the second to complete the weld. A direct current resistance weld controller that incorporates closed loop feedback to control the weld energy was used in this preliminary study. Since titanium has a very high electrical resistance, standard RWMA #2 material was used for both the upper electrode and the cover holder (lower electrode).

The three critical weld factors associated with nearly all resistance weld processes are power, electrode force and weld time. Obviously, there are many other factors that may affect weld quality, such as feature size, hold time and electrode geometry, so it's always a good idea to conduct a screening design of experiments (DOE) to develop a resistance weld process. This will help produce an optimal process window and identify the critical factors.

Table 1 shows the DOE factors and non-DOE (i.e. constant parameters) used for this initial 5 factor half-factorial DOE, which resulted in a total of 16 runs.

Weld Schedule	Constant	Low	High	Unit
Squeeze Time	100	-	-	ms
Electrode Force	-	4	6	lb
Pulse 1 Up	10	-	-	ms
Pulse 1 Dwell	-	5	15	ms
Pulse 1 Energy	-	0.35	0.65	kW
Pulse 1 Down	0	-	-	ms
Cool	10	-	-	ms
Pulse 2 Up	10	-	-	ms
Pulse 2 Dwell	-	10	30	ms
Pulse 2 Energy	-	0.75	1.25	kW
Pulse 2 Down	0	-	-	ms
Cool/Hold	100	-	-	ms

Table 1. DOE Weld Schedule Parameters and Values

Once in production, it's important to capture both individual and group data to control the process. In this investigation, modern weld management software was used to perform the DOE and collect all process data from the weld controller and store it in a central database. The software was also used to record the two response parameters. The first was variable data, namely the ball push-out force, while the second was attribute data, namely the welded ball's visual appearance.

DOE Analysis

The push-out force response was analyzed and ranged from a low of 5.7 lbs. to a high 43.8 lbs., with 'Pulse 2 Energy' and 'Pulse 2 Dwell' being the statistically significant factors. Not surprisingly, the highest push-out force occurred with the treatment that had all high side values in Table 1. In this analysis, it's assumed that push-out force is a good indicator for electrolyte retention because it implies a solid weld joint and a hermitic seal.

Figure 2. Projection Weld Top Views, Expulsion (left) No Expulsion (right)

Figure 3. Projection Weld Cross-section (35X magnification)

The visual response attribute data was analyzed and revealed 'Electrode Force' and 'Pulse 2 Energy' were significant factors. However, even though high side pulse 2 energy produced high push out forces, there was severe material expulsion. Figure 2 shows a typical high pulse 2 weld energy and low electrode force on the left and a low pulse 2 energy and high force on the right. In fact, all runs using low force and a high pulse 2 energy produced significant material "blow-out". Note that runs with low pulse 2 energy and high electrode force still had respectable push-out forces of around 21 lbs.

A cross-section of a low pulse 2 energy, high pulse 2 dwell time, and high electrode force is shown in Figure 3. Notice that the top of the spherical ball is flattened, due to the heat during the projection weld, and only projects 0.005 inches above the surface of the cover. Visual inspection seems to indicate that a hermetic joint was produced, but only a helium leak test would be able to confirm.

Waveform Signal Analysis

In addition to capturing summary weld data like peak and average voltage, power, current and resistance, comprehensive weld management software will leverage a weld controller's built-in monitoring capabilities by capturing the waveforms too. This allows a manufacturer to capture and analyze valuable waveform data, which along with modern signal analysis techniques, can be used to detect bad welds. Figure 4 shows the weld curves for the part exhibiting visual expulsion in Figure 2.

The voltage waveform clearly has voltage ripple during the second pulse dwell period, which differs markedly from the smooth exponential decay for parts without expulsion. In production, this failure mode could be detected without visual inspection, by using waveform pattern matching, a standard feature in high performance resistance weld software.

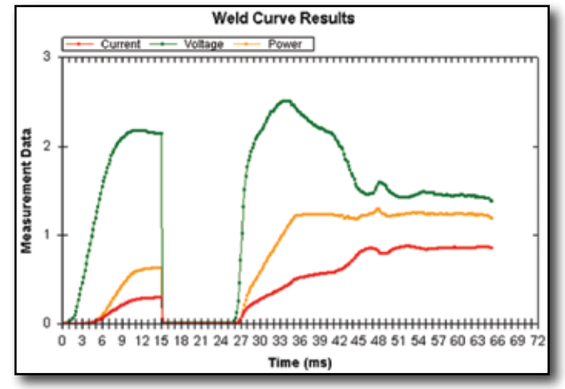


Figure 4. Projection Weld Expulsion Waveforms: Power (yellow), Current (red), and Voltage (green)

Conclusion

This article discussed the advantages to resistance projection welding and common joint configurations to realize them. A small scale resistance weld study was performed on a medical device battery cover and fill port ball to better understand the process. The preliminary study showed that pulse 2 energy, dwell time and force are important parameters. Further study would need to be done to confirm that high push-out force correlates with joint hermiticity. Weld monitoring signals, such as voltage, appear to have distinct signatures in the event of weld expulsion and could be used with modern weld management software to keep the process in control. Resistance welding is a low cost manufacturing method and can provide a robust weld joint in critical applications.

Contact techMatrix, LLC at www.techmatrixllc.net.

Despite Advances in Portable Electronics, a Device is Only as Reliable as the Connector that Holds the Battery

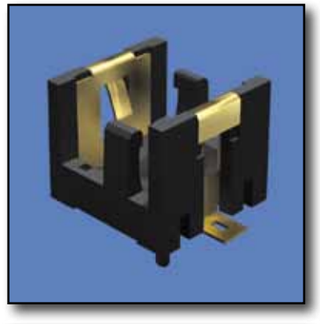
Larry Nembhard, Chief Engineer
Keystone Electronics Corp.

The future of batteries, like that of so many of the products they power, is clearly toward smaller, lighter and more powerful models. Developing concurrently with these new battery designs are battery connectors. As battery connection devices evolve, they have to meet a number of challenges including rapid growth of designs, rugged construction, high-density packaging, manufacturing costs and environmental concerns.

Perhaps no device has undergone such continual evolution and development in the last 50 years as the portable primary power source, the battery. Portability, miniaturization and computerization in electronic devices have driven a good deal of this change. Common applications now include power source and memory backup for computers, cell phones, remote controls, cameras, control/assist in automotive, utility meters, data loggers, emergency tracking systems, security systems, RFID tags, defibrillators, other sophisticated medical and military applications.

Driven by these many applications, changes are being seen in a variety of battery characteristics. Where alkaline and nickel cadmium once dominated, now lithium-ion (Li-Ion) batteries are commonly used in portable consumer electronics because of their high energy-to-weight ratios, lack of memory effect and slow self-discharge when not in use. In addition to consumer electronics, Li-Ion batteries are also being used in defense, automotive and aerospace applications. These lithium cells are used not only for memory backup applications, but are now the primary power source for mobile electronics.

The result is that the Li-Ion batteries are now available in a variety of shapes and sizes.



Performance Goals

Regardless of change, the goals in battery development over the years have remained the same: longer life, smaller and lighter packages, increased power delivered, economically and safety. Different applications, however, have different factors determining the type of battery required. When such factors are designed for, they become the features that achieve performance goals, such as new high rate cells that fulfill the most reliable high-power output with low space requirement and with high pulse current drain.

Low self-discharge is another performance goal leading to longer shelf life. Today, a five year shelf life for lithium cells is common and 10 years is common in certain demanding commercial and military applications. The lithium coin cells used for memory backup in computers are likely to outlast the hardware they are used in.

These examples demonstrate that as electronic products have grown, different demands requiring different designs have driven the evolution of the chemical battery. That is not all that has evolved, however.

Battery Connections

There is a direct connection between the battery and the device it powers. The bridge between them is the connection device, and this has had to evolve as well. There was a time when battery connectors were simply stamped, plated and then riveted onto printed circuit boards and soldered. Early battery connectors were crude compared with today's devices, which are often major components incorporating sophisticated interconnection technology. As battery connection devices have evolved, they have had to meet a number of challenges. Lithium batteries can be dangerous if not used properly; improper use can cause Li-Ion batteries to explode, therefore the holders and retainers must be design to prevent such occurrences.

Rapid Growth of Designs

There are virtually as many battery holders, retainers, contacts, clips, straps and snaps as there are cell or battery configurations. Most configurations today are designed so that the batteries can be quickly and easily installed and/or replaced. Many are available on tape-and-reel in addition to loose piece. They come in horizontal and vertical mount configurations, with single or multiple contacts for series and parallel applications. These connectors are used on PCBs or in self-contained battery compartments. They may include such features as insulated polarization designs, inverse polarity protection and battery retention latches.

Rugged Construction

When batteries were larger, contacts could be larger. With the trend toward smaller and lighter designs, lighter contact forces must still provide reliable connections. They have to be just as rugged as former connections to hold the battery securely while withstanding shock and vibration, but at a fraction of the size and weight.

One solution to the problem of balancing strength and size has been to employ holders and retainers design and manufacturing technology to develop battery holders constructed of a combination of plastic and metal subcomponents.

Demanding applications where cost and space is a concern, stamped contacts and clips are used, such as the toy industry and promotional throwaway products. Retainer clips are available to lock the batteries in place while offering the lowest possible profile and prevent loosening or shifting of the battery.

Design Considerations

Lower voltages and less amperage affect engineering on both sides of the connection. For example, less contact resistance is imperative, so contacts need to be made of the proper materials for given applications. Where such alloys as phosphor bronze and beryllium copper were once reserved for high-performance interconnects, they are now used in battery contacts as well.

Another design consideration is how to prevent the battery from being put in the wrong way. By polarizing the contacts, the battery holders assure proper continuity and circuit protection.

High-Density Packaging

With space at a premium in many commercial and consumer electronics, not only the batteries, but also the holders and retainers are following a trend toward miniaturization. As a result, low-profile holders and compact battery contacts are necessary. These components must be compatible with pick-and-place assembly systems; they should be balanced and lightweight for reliable tape packaging and machine pick-up and placement.

Manufacturing Costs

Today, the cost of materials, including specialized plating, has made tooling an integral part of any application. Holders and retainers have to remain economical while providing reliable performance. Many manufacturers must use high-speed presses to reduce cost for stamped contacts. Molds must be design with multiple cavities to reduce run time. Standard stock parts are made available to meet most applications.

Environmental Concerns

In the past there were few if any environmental concerns regarding battery disposal. Recognizing the devastating effect that lead, cadmium and lithium, among other metals, have on the environment, the government now regulates the disposal of batteries. Regulation, in turn, has encouraged the development of battery holder designs that allow the batteries to be removed quickly and safely. The use of an inexpensive but durable connection solution is seen in numerous battery clip designs in today's computers and electronics. When PCBs are disposed of, the batteries on the boards may be disposed of separately. With the latest battery connectors, taking out a battery is as easy as putting it in. The battery holders and retainers have to be environmentally friendly and must be RoHS compliant.

Conclusion

The future of batteries, like that of so many of the products they power, is clearly toward smaller, lighter and more powerful models. Innovation is the order of the day. Developing concurrently with these new battery designs are battery connectors. Suppliers of battery connection hardware must now have their own in-house engineering and testing departments to keep up with the demand. They have come up with low profile, lightweight, yet durable battery connector designs that are available in the most up-to-date packaging formats for automated placement.

Contact Keystone Electronics Corp. at kec@keyelco.com or www.keyelco.com.

Safety and Protection for Advanced Lithium Batteries

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Lithium-ion (Li-Ion) batteries have increasingly become the enabler of modern portable technology products ranging from laptop computers, communications handsets and medical equipment. Contemporary Li-Ion cells offer energy densities that are significantly higher than legacy battery chemistries such as nickel cadmium (NiCd), nickel metal hydride (NiMh) and lead acid (LA). Smaller form factor and weight of Li-Ion cells enable the development of compact, feature-rich products with long run times. Although the advantages of Li-Ion cells make them particularly attractive, they must be used in conjunction with advanced protection circuits. Development of advanced Li-Ion battery packs requires expertise and experience in order to balance system load demands with reliability and safety.

Due to their volatile nature, Li-Ion cells must be protected by additional layers of safety. When developing a safety circuit, design engineers should consider the required levels of protection, redundancy, compensation for excessive load transients, protection settings and special application requirements.

Levels of Protection

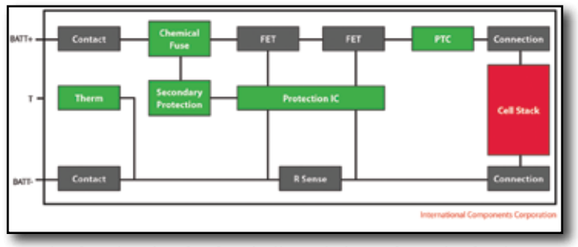
Before proceeding, it should be noted that there is a significant difference between a cell and a battery pack. A cell is considered the basic component that stores and releases charge. NiCd, NiMh and LA cells can be used without additional levels of safety as they are generally non-volatile. Li-Ion cells, however, need safety components and circuits to monitor and manage the charge/discharge cycles and prevent inadvertent application and mishandling. Only after those circuits are added could such systems be considered batteries. That is why development of Li-Ion battery packs is often much more elaborate than construction and assembly of standard batteries.

One level of protection to an advanced Li-Ion battery pack is the PTC, or positive thermal coefficient device. It reacts to high current discharge levels to increase output impedance. The increased impedance controls output current and the PTC can disconnect the output path if the discharge levels exceed safe limits. Most contemporary high energy cylindrical Li-Ion cells incorporate a PTC, eliminating the need, cost and complexity of adding such a component.

Another more active level is often the charge/discharge monitoring cutoff circuit. Controlled by the protection IC, this circuit monitors charge/discharge levels and activates/deactivates the relative transistors (switches) to allow or inhibit current flow. This works in combination with the PTC to prevent unwanted side effects of overload or short circuits. Cutoff circuits often utilize a thermal sensor to monitor individual cell temperatures and also trigger accordingly.

Individual cell monitoring circuits provide an additional level of protection. These circuits respond to cell imbalance conditions in packs with multiple cells connected in series. The absence of individual cell monitoring circuits can lead to cell imbalance, which can result in uneven or excessive charging and discharging of individual cells. If any of the cells connected in series exhibits levels significantly different from other series cells, the cell monitoring circuit triggers the cutoff process.

Chemical fuses are also utilized to provide permanent circuit interruption, if it ever becomes necessary. These fuses are controlled by the cell monitoring and cutoff circuits. If activated, the fuse permanently disables the battery pack and prevents current flow. Although it may appear extreme, such actions are sometimes necessary if the battery is subjected to over-charge, over-current or deep discharge conditions.



The four levels of safety indicated above form the fundamental protection system for many Li-Ion battery packs. Medical devices often require all four levels in order to provide redundant measures of protection. In some cases a PTC-only approach could be considered adequate, but medical devices should incorporate all available forms of protection.

Potential Drawbacks of Excessive Protection

There is a potential drawback to having too much protection and it should be noted that all safety functions are designed to operate only when the battery is subjected to an abuse condition (over-charge, over-current or deep discharge). In applications with high transient or instantaneous loads the design challenge is developing a circuit that accurately determines the difference between a short circuit condition (over-current) and normal operation of the equipment. Furthermore, inadvertent or nuisance operation of safety functions could become a safety hazard if the medical device is vital to a life sustaining function. This places the responsibility on battery pack development engineers to design a safe, yet reliable pack.

Determining Firmware Settings

In certain situations a battery pack may face momentary transient loads that exceed optimal levels. Although excessive loads are usually detrimental to Li-Ion cells, their effects can be mitigated by proper load analysis. If overlooked, these brief load spikes can impact the reliability of the battery pack by causing

inadvertent activation of protection circuitry. Design engineers must be able to balance safety, reliability and robustness when developing an advanced battery pack.

No matter how accurate the models are and how much real world simulation testing is performed, it is often not possible to accurately model peak transient loads. This is especially true in motor-driven devices. PTC protection is mostly benign and will not react quickly enough to short overloads, but active protection circuits must be developed with appropriate reaction time and hysteresis.

Protection circuit reaction time is determined by parameter settings in the control IC firmware. Design engineers have options of not only setting the critical thresholds, but also time constants for reaction time. A protection circuit could be made to react faster or slower to a transient event by varying the time constants. It should be noted that transient events do not always have to be excessively high transient spikes. Momentary loads can induce temporary cell voltage dips to below minimal values. Although this is not desirable, it is permissible for brief periods.

In addition to thresholds, engineers can modify the firmware settings to control the hysteresis of a particular circuit. Hysteresis could be viewed as the desired lag between an initial trigger event and the point at which the circuit resets. By adjusting the protection threshold hysteresis appropriately, designers can ensure that a battery pack will not enter an undesirable oscillation mode between a fault condition and subsequent relaxation.

The Effect of EMI

It should also be noted that active protection circuits must be resilient to electromagnetic interference, or EMI. Electromagnetic energy can induce a voltage potential across key protection circuit sense lines or components, inducing a fault condition. This is especially the case in products that are likely to be used near the sources of significant EMI, such as MRI and X-ray machines. General protection circuits are self resetting, but chemical fuse applications should especially be evaluated in such cases. Inadvertent triggering could render the pack permanently disabled.

Conclusion

Li-Ion technology is at the forefront of advanced battery design. Device manufactures are transitioning from legacy chemistries to take advantage of the many benefits Li-Ion has to offer. Additional hardware and software must be applied to Li-Ion cells to ensure safe and reliable battery pack operation. This article outlined the various levels of protection, reviewed firmware setting options and discussed EMI considerations, all necessary elements for an advanced Li-Ion battery pack design.

Based on the complexity of the today's battery pack design, OEMs will find it advantageous to partner with an expert in battery pack development. Companies such as International Components Corp. (ICC) provide device makers with state of the art battery pack designs that meets today's design challenges.

Marko Dimitrijevic has a B.S. degree in Electrical Engineering and an M.S.C. in Engineering Management along with 11 years experience developing Base Radio Switch Mode Power Supply hardware, mobile device battery management, Lithium-ion battery chargers and protection circuitry. Marko currently works as an applications engineer at International Components Corp.

Contact International Components Corp. at www.iccus.com.

Lithium-Ion and Regulations:
Updating from a Storm Watch to a Storm Warning

Dr. Kerry Lanza
Palladium Energy

"Ladies and gentlemen, before takeoff, please stow your tray tables and put your seatbacks in their full upright and locked position. For your safety, please hand over your cell phones, laptops, MP3 players, cameras, DVD players and anything else with a lithium-ion battery in it." Lithium-ion batteries, the rechargeable energy source that has made our modern, on-the-go life possible, are under scrutiny. This time from the airline industry.

Why are lithium-ion batteries getting this focus from the airlines? In 2009, there were an estimated 3.3 billion lithium-ion batteries transported globally, an 83 percent increase over 2005 (PHMSA, 2009). The estimated failure rate of lithium-ion batteries is one failure per 10 million manufactured, and it is even lower in the transport environments. Despite the positive safety record associated with lithium-ion batteries, the US Department of Transportation (DOT) is concerned about the potentially catastrophic consequences of a lithium-ion battery incident in the air.

Incidents in the News

Since lithium-ion batteries have started being used to power portable devices about 20 years ago, the number of airline passengers have increased 38 percent to 1.8 million people flying per day. During that same period, the Federal Aviation Administration (FAA) has documented 92 transport related incidents involving lithium-ion batteries and lithium-ion powered devices. Some of these incidents have received front page headlines. In February 2010, a United Parcel plane full of packages, including lithium-ion batteries, was engulfed in flames while landing in Philadelphia. While investigators have not reached a final ruling, they continue to review the melted shipment of lithium-ion batteries. In 2004, a plane carrying Vice Presidential candidate John Edwards made an emergency landing when a lithium-ion battery exploded in the hand of a television camera man. Just before take-off on a Lufthansa flight from Chicago to Munich in 2006, smoke began to bellow out from the overhead compartment above seat 2A. The crew grabbed fire extinguishers, opened the compartment and saw a carrying case in flames. After putting the fire out, they tossed the case out onto the ramp. Passengers watched as fire trucks and bomb squads roared onto the scene. But they found no terrorist device, just a charred laptop and a "six-pack" of melted lithium-ion batteries (Dade, 2006).

How to manage such a low probability and high consequence risk poses a great challenge to the DOT. The increasing demand for higher performance portable electronic devices that require smaller, more powerful batteries forces battery manufacturers to pack more active material into the limited volume of a battery case. Increased production of smaller, more powerful batteries creates a situation where batteries are more susceptible to an incident. Preventing an incident involves working with the battery industry to develop safety standards that are in line with the rapid change in demand for higher power batteries and developing effective practices to reduce risk. Before any new regulations can be enacted, it is prudent to look at the causes of failure, as well as the depth and breadth of current regulations.

Lithium-Ion Failure Analysis

The most likely causes of the lithium-ion incidents can be categorized into the following causes:

External Short Circuit: occurs when an exposed battery terminal contacts a metal object. When this happens, the battery will heat up causing ignition of the battery and any surrounding combustible materials.

Improper Use: generally regarded as improper charging and discharging associated with equipment use, inadvertent activation and overheating.

Non-Compliance: includes faulty battery design, false certification with regulatory and testing requirements, and improper packaging and handling, including counterfeit batteries.

Internal Short Circuit: caused by foreign matter introduced into the cell or battery during the manufacturing process. An internal short circuit can occur when a battery is physically damaged when dropped or punctured.

Current Regulatory Maze

For lithium-ion batteries and devices, a variety of agencies, regulations and certification bodies currently exist in a literal alphabet soup of alpha-numeric designations. There are US entities, European organizations, Japanese standards and individual industry standards and regulations. These standards, certifications and regulations have significantly improved lithium-ion battery and device safety. Some of these rules are just guidelines, while others are statutory (legal) requirements. Still others, while not mandatory, are necessary if a company wants to sell and market their products as being safe. Some of the significant organizations and rules include:

US/DOT and UN/DOT: In the US, 49 CFR defines shipping regulations for lithium-ion batteries. The United Nations (UN) defines regulations and testing requirements for safe packaging and shipping lithium-ion batteries globally.

UL: Underwriters Laboratories is an independent certification organization. Key standards for lithium-ion batteries include UL 1642 and UL 2054. With some overlap, these standards set safety guidelines for individual and replaceable Li-Ion batteries.

IEEE: The Institute for Electrical and Electronics Engineers have developed IEEE 1625 and 1725 standards. IEEE 1625 provides comprehensive system (battery and device) safety guidelines for laptop batteries. IEEE 1725 pertains to analogous system safety rules for cell phones.

CE: The European CE mark is a manufacturer's self-declaration that the device meets requirements for European Union product safety.

CTIA: The Cellular Telephone Industry Association is an international group that certifies compliance to IEEE 1725.

IEC: The International Electrotechnical Commission is a non-profit organization writing international safety standards. The IEC 62133 standard appears to be approaching acceptance and includes a very strict overcharge cell test.

Pending Regulations

So, what is the regulatory storm on the horizon? The US Department of Transportation (DOT) is proposing some lithium-ion battery pack packaging and shipping rules changes. Basically, the changes will eliminate exceptions for small lithium battery packs. These changes, if promulgated, will make significant modifications to shipping regulations of lithium-ion battery packs and the devices containing these packs. Implications to the changes include:

- Small cells shipped via air will have to be classified as a Class 9 Hazardous Material
- These changes will force new labels and packaging requirements
- No grandfathering is allowed, so retesting of existing packs will be required
- Additional training will be needed for employees handling the packaging

The only group really supporting the changes is the airline pilots union; ironically, even the airlines and air-freight companies do not support the changes. The Rechargeable Battery Association has calculated first year costs to the industry for compliance to be more than $1.1 billion. Re-occurring costs will be in excess of $8.5 billion over 10 years. It is well documented that when problems have occurred with lithium batteries, it is because they were not packaged according to the existing laws and regulations.

Alternative Solutions

It may make more sense to see harmonization with international standards rather than total revocation of any exceptions. The International Civil Aviation Organization (ICAO) currently requires that all packaging containing lithium-ion batteries (less than 100 Whr) be packed in an inner packing, weigh no more than 10 kg, have an outer label of caution/handling, and the outer packing with its content being able to withstand 1.2 m drop. Only secondary lithium batteries >100 Whr should be shipped as Class 9.

Removal of exceptions from Class 9 shipping will only punish manufacturers who are committed to support the needs of their customers and adhere to all regulations to maintain safety. It will take DOT several months to review the changes, plus they have to review the changes with other government agencies. Nevertheless, I suspect that the changes are coming and we will have to work with it. The Greek philosopher Epicurus said "The greater difficulty, the more glory in surmounting it. Skillful pilots gain their reputation from storms and tempests."

Dr. Kerry Lanza is strategic marketing manager at Palladium Energy. Palladium has expertise in lithium-based technologies for battery packs that power portable and backup applications across various verticals including medical, data capture, data storage and consumer electronics.

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Contact Palladium Energy at www.palladiumenergy.com.

Powerex Imedion Family

Maha Energy has introduced new additions to the Imedion Ready When You Are line of rechargeable batteries. The Imedion batteries come pre-charged and have low shelf-discharge characteristics. They are now available in all sizes including: AAA, AA, C, D and 9 V.

Unlike traditional NiMH batteries, Imedion can be stored for an extended period of time without substantial loss of power and are ready to use out-of-package. A common problem that plagues rechargeable batteries is that they need to be recharged about once every one to three month even if they are not used. Maha tackled this issue by developing advanced electrode materials to reduce the rate of power loss during storage. As a result, the Imedion batteries retain up to 85 percent of its charge even after one year of storage (at a room temperature of 20°C).

East Penn Releases Two New Front Access Unigy High Rate Batteries

East Penn Manufacturing continues to expand its High Rate front access battery line by releasing the Unigy HR3500ET and HR7500ET batteries with a 10-year design life for UPS service.

East Penn's front access terminal configuration provides a space saving and safer design for high-powered battery systems. By reducing the additional clearance needed for top connections and longer cable lengths, UPS installations that utilize East Penn's front access battery design can maximize efficiency and long-term savings while achieving more power in less space. Installation and monitoring are streamlined and safety is significantly improved by eliminating the need to reach over the batteries to access the terminal connections.

Unigy High Rate batteries feature exclusive IPF Technology that ensures the full formation and inspection of every plate. This optimizes power capacities and ensures consistent cell-to-cell voltages critical to long-life reliability.

Saft Introduces Li-Ion Battery Technology for Marine Propulsion and Auxiliary Systems

Saft has introduced its advanced lithium-ion (Li-Ion) battery technology that offers interesting new possibilities for the creation of highly efficient and cost-effective marine propulsion and auxiliary systems. Li-ion battery technology can offer a number of key advantages for designers in the marine industry, including high-power and/or energy storage in a compact space and weight-saving package, high-efficiency, long calendar and cycle life (even when operating in extreme temperatures), and zero-maintenance requirements.

Saft anticipates that Li-Ion technology will be of particular interest for hybrid propulsion systems in which the batteries work in conjunction with diesel, or possibly gas turbine, generators and electric motors. The specific advantages of this hybrid power approach will vary according to the type of application.

Hybrid power could offer significant improvements in fuel efficiency and CO_2 savings for work boats that spend most of their time at sea moving into position and only operate at full power for very short periods. So rather than sizing a diesel engine for peak power, it can be specified at a more economical size for average power, with extra power drawn from the batteries, when required.

In leisure boats, such as yachts, a hybrid system will enable the vessel to switch to battery power for silent, low-speed running when entering harbour, helping to meet the growing demand from port authorities to reduce CO_2 emissions. The battery could also support hotel loads when the yacht is moored, providing a green, quiet and vibration-free alternative to running diesel-generators, especially when waiting for access to harbour power points.

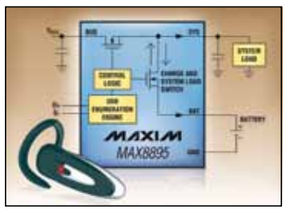
Contour Energy Systems Announces Next-Generation Coin Cell Batteries

Contour Energy Systems, Inc., a portable power company commercializing next-generation battery systems, will be releasing its first line of coin cell batteries with availability starting in the fourth quarter 2010. Contour's new line of lithium coin cells, based on its patented Fluorinetic battery technology, offers OEMs significantly longer battery life and other performance advantages for multiple device categories and applications spanning automotive, consumer, industrial and medical markets.

The coin cell product line from Contour will feature four primary advantages: greater runtime, improved discharge rates, longer shelf life and safer environmental design compared to current lithium products that can contain heavy metals, perchlorate and other dangerous and caustic materials. The use of a solid cathode with no heavy metals or other toxic materials minimizes safety and environmental concerns. 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.

Battery Charger with Automatic USB Enumeration

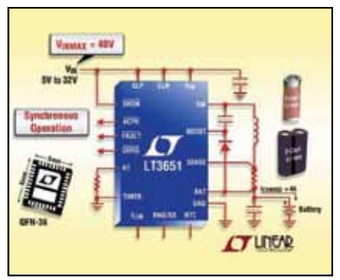
Maxim Integrated Products has introduced the MAX8895, a linear battery charger for Bluetooth headsets and portable devices that is compatible with the USB Battery Charging Specification, Revision 1.1. The MAX8895 is equipped with automatic adapter detection for distinguishing between USB devices, USB chargers and dedicated chargers. It also integrates a USB enumeration function that automatically negotiates with the USB host to optimize charging current without processor intervention. This capability eliminates the need for a separate microcontroller and system software, thus providing the industry's only stand-alone charging solution.



The MAX8895 integrates a battery-disconnect switch, current-sense circuit, thermal-regulation circuitry, MOSFET pass elements and overvoltage protection (OVP) up to 16 V , providing an easy-to-implement, extremely compact charger solution. Flexible programming options include fast-charge current, termination current, and charge timer duration. The MAX8895 also supports adaptive battery charging, which reduces charge current when necessary to prevent the charge source from collapsing.

Synchronous Monolithic One-Cell Li-Ion/Polymer Battery Charger Delivers up to 4 A Charge Current

Linear Technology Corp. has introduced the LT3651-4.2, a highly efficient, 4 A monolithic synchronous buck battery charger for one-cell Li-Ion/Polymer batteries. The LT3651-4.2 accepts inputs up to 32 V with a 40 V absolute maximum rating for added system margin. Charge current is programmable and dynamically adjustable up to 4 A; fully integrated synchronous power devices minimize power dissipation and save board space. User-selectable timer or C/10 termination requires no external microcontroller and simplifies the design. The LT3651-4.2 does not require external high-precision resistors to set the float voltage, further saving cost and space. Applications include industrial handheld instruments, 12 V to 24 V automotive and heavy equipment applications, desktop cradle chargers and notebook or tablet computers.



Energizer Introduces Inductive Charger to Meet Demand for Wireless Power

Energizer has introduced their first inductive charger built with Qi technology, the new universal charging standard developed by the Wireless Power Consortium (WPC).

Widely anticipated and considered to be one of the most compelling new developments in charging technology, Qi (pronounced chee) will bring consumers the freedom to charge their smartphones, MP3 players, cameras (any device 5 watts or less) on a single charging station, regardless of manufacturer.

Designed in cooperation with WPC co-founder ConvenientPower, the first generation of the Energizer Inductive Charger is designed to conveniently charge up to three devices at one time. It features two large inductive charging zones that don't require locking the device into a precise position, so consumers can simply set down their phone and be sure that it will be charged and ready to go. It also has a USB port so it's easy to charge an additional device such as a phone, headset, MP3 player, camera or GPS. Two LED charge lights indicate that the device is charging.

Inductive charging is what happens when two devices, one designed to send power and the other designed to receive it, touch one another and energy is transferred between them. By using an electromagnetic field to transfer energy, charging pads are able to intelligently communicate back and forth with the devices they're charging.

Before Qi, transmitters and receivers had to be designed to work together, or speak the same "language." Now, Qi is the common language for inductive chargers and devices to talk to one another, so any device with a Qi-enabled accessory or with Qi built directly into it can charge on any Qi inductive charging pad.

Phihong Develops Low-Cost European Charger

Phihong has developed a small, low-cost 2.75 W USB charger. Measuring 42 mm by 43 mm by 21 mm with a weight of 80 grams, the PSM03E is compliant with the new Energy Star EPS version 2.0 as well as the European Union's Ecodesign Directive 2009/125/EC for Energy-related-Products level 2 Annex 1b, and the 5-Star Standby Power standard. The small size of the charger makes it well suited for wireless communications, peripherals, networking, portable and mobile equipment.

Designed for applications such as MP3 players, PDAs, digital cameras and mobile phones, the PSM03E provides a fully regulated 5 VDC output and a maximum no-load power consumption of <0.03 watts. The device is IEEE1725-certified for charging batteries in mobile phones.

The USB mobile charger has a constant-current/constant-voltage feature, which allows for a quick charge on lithium ion batteries minimizing downtime for a user's mobile device.

The standard mobile charger also includes a low-profile case that is halogen-free and therefore will not give off toxic smoke in the event of a fire. The charger contains short-circuit protection, over-current protection and over-voltage protection. The functional operating temperature is between 0°C to 45°C. The adapter also meets RoHS, REACH and WEEE directives and is marked for CE compliance.

Liebert GXT3 On-Line UPS 5 kVA to 10 kVA Models to Increase Power Capacities in Small Spaces

The increasing demand for rack-backed computing capacity, and the IT systems and equipment necessary to deliver that capacity, is stretching the limits of existing data center spaces. With that in mind, Emerson Network Power has introduced the Liebert GXT3 uninterruptible power supply (UPS) system in 5 to 10 kVA models. The true on-line double conversion Liebert UPS system, which is an extension of the existing Liebert GXT3 product line, enables IT managers to pack higher power capacities into smaller spaces while maintaining best-in-class availability.

The Liebert GXT3 can be installed in a rack or tower configuration, with a rotating LED display panel that adjusts accordingly. The Liebert UPS features replaceable, hot-swappable internal batteries that provide four or more minutes of runtime at full load, with higher backup time available at typical loading conditions. The 5 kVA and 6 kVA models require 4 U of space, while the 8 kVA and 10 kVA models require only 6 U of space. Optional battery cabinets, adding 2 U to 4 U of rack space, provide additional runtime via the plug-and-play connections on the rear panel of the UPS.

Trilogy DC Power System Offers the High Power Conversion Efficiency with an Innovative Twist

Eltek Valere has announced the Trilogy DC power system, a 40 A to 600 A, 48 V high-efficiency (HE) power system with 15-inch shelf depth and special cable management to fit into short-depth outside plant and central office applications.

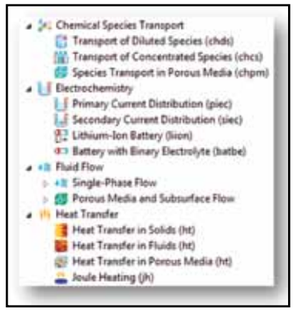
Although not exclusive to solar applications, the Trilogy DC power plant does offer convenient solar energy management, allowing service providers to use the sun as a back-up power source without the need for a separate, discrete power plant. This capability is made possible with the Smartpack controller, standard with the Trilogy system, which can manage AC power input from the grid and DC solar energy input from a solar array to optimize power conversion.

Trilogy can be configured in a two-shelf system for up to 300 A of power, a three-shelf system for 400 A of power or a four-shelf system for 600 A of power. The shelves can fit into a 19- or 23-inch rack. The high efficiency of the system also significantly reduces heat output compared to the industry standard power efficiency, lowering the amount of cooling needed.

For solar applications, the Trilogy utilizes 48 V Flatpack2 HE Solar Chargers to convert solar energy to usable DC power. The solar converters provide output power of 1,500 W with 96 percent power conversion efficiency. Each solar charger module utilizes maximum power point tracking (MPPT) technology to optimize solar output and utilization of the free energy from the sun collected by a solar array.

Batteries and Fuel Cells Module for COMSOL Multiphysics Released

COMSOL, Inc., the developer of the COMSOL Multiphysics simulation software, has released the Batteries & Fuel Cells Module for COMSOL Multiphysics modeling and simulation environment. This new, optional expansion module provides a full set of tools for the set-up, simulation and study of all major electrochemical batteries and fuel cells, including lithium-ion and nickel metal-hydride batteries, solid oxide and proton exchange membrane fuel cells. With the Batteries & Fuel Cells Module engineers, scientists and researchers can investigate in detail the influence of different materials, geometric configurations and operating conditions on the performance of batteries and fuel cells quickly and accurately.



The Batteries & Fuel Cell Module for COMSOL Multiphysics enables integrators and developers of batteries, fuel cell components, and fuel cell stacks in such industries as transportation, green energy and consumer electronics to obtain accurate and reliable simulation results quickly. The COMSOL Multiphysics environment is engineered to facilitate the simulation of multiple, coupled physical phenomena, making it well suited for simulating the behavior of batteries and fuel cells where multiple, coupled physical mechanism are ever-present. The Batteries & Fuel Cells Modules extends COMSOL Multiphysics with predefined couplings of electrochemical reactions, flow, heat transfer and electric fields. Users leverage this powerful combination to quickly set up and model the behavior of their battery and fuel cell designs using real-world materials and operating conditions.

Snap-Fit Valve Base for all Philadelphia Scientific Water Injector Systems Enables Fast Installation

Philadelphia Scientific has introduced a new snap-fit valve base for its entire line of Water Injector Systems. The snap-fit base eliminates the need for a separate quarter-turn adaptor, making installation of Philadelphia Scientific Injector systems faster and easier than other single-point systems. This feature saves users time and money. The snap-fit valve bases were previously available only on the Water Injector Spider System.

The snap-fit base is easily installed by simply removing the vent cap from each battery cell and pushing the Water Injector valve into place. Once installed, the valves can be rotated as needed to enable effortless installation of the system.

New PC Clip for Lithium-Ion Batteries

Keystone Electronics is meeting the increasing demands to accommodate higher energy, lower weight, rechargeable batteries placed in mobile products with the introduction of a low profile, thru-hole PC Battery Clip for Lithium-Ion size cells from 17 mm to 19 mm diameter.

Engineered to withstand the rigorous use associated with recharging cycles, in addition to shock and vibration, the clip features a three-legged, THM design for extra strength and stability plus low profile placement into dense PC boards.

The design is manufactured from 0.012 inches (0.30 mm) thick, spring steel, with Tin Nickel plate finish. It holds battery cells firmly and securely in position and is specifically suited for higher energy, lower weight portable electronics for medical, telecommunications and industrial usage.

Saft Wins Order for Lithium Batteries to Power Universal Ground Control Station

Saft has received an order for lithium-ion (Li-Ion) batteries from AAI Corp. to supply back-up power for its Universal Ground Control Station (UGCS), which controls Unmanned Aircraft Systems (UAS). The 28 V batteries are capable of integrated charging, a feature that strengthens and simplifies the powering system.

The high-energy, yet low-weight batteries have a capacity of 100 amp/hours and are made up of 16 VL 52E cells in a 2P8S configuration. The batteries will provide emergency back-up power for a flight-critical function of the UGCS. In the event of a power failure, the battery will activate, allowing the UGCS to carry out its UAV control mission.

"The development of an Integrated Charger Battery (ICB), along with this order, adds to Saft's experience in complete systems for energy storage applications," said Thomas Alcide, general manager of Saft's Specialty Battery Group. "This large defense order further demonstrates Saft's ability to meet demanding power supply needs for a range of field-critical applications."

The batteries accept universal AC input and provide 28 VDC output. While simplifying and reducing the size of the system, the ICB function eliminates the need for an additional power source to charge the battery. ICB capability is a unique technology that Saft will apply to other systems in the future.

AAI Corp.'s UGCS architecture meets US Army and joint services interoperability requirements, as well as UAS joint information exchange capabilities for command, control, communications, computers, intelligence, surveillance and reconnaissance or C4ISR. The system is designed for US joint services interoperability requirements, including simultaneous mission control of multiple unmanned aircraft.

A123 Systems Opens the Largest Li-Ion Automotive Battery Manufacturing Plant in North America

A123 Systems, a developer and manufacturer of advanced Nanophosphate lithium ion batteries and systems, has announced the grand opening of the largest lithium ion automotive battery production facility in North America. The new plant in Livonia, Mich. is expected to expand A123's manufacturing capabilities by up to 600 MW hours per year when fully operational, contributing to the company's plan to expand global final cell assembly capacity to more than 760 MW hours annually by the end of 2011. The opening of the Livonia factory comes just over one year after A123 was awarded a $249 million grant from the US Department of Energy (DOE) as part of the American Recovery and Reinvestment Act to help the company execute its strategy to ramp up US manufacturing capabilities to meet increasing, market-driven demand for its technologies.

A123 will focus on manufacturing prismatic cells and systems at the new 291,000-square-foot facility. The factory is designed to enable the complete production process, including research and development, manufacturing of high-value components, cell fabrication, module fabrication and the final assembly of complete battery packs ready for vehicle integration. As part of its continuing US manufacturing ramp up, A123 also plans to open a coating plant in Romulus, Mich., expected to come on line during the first half of 2011. In addition to the DOE grant, the company received $125 million in state incentives from Michigan as part of its 21st Century Jobs Fund to help finance these manufacturing facilities.

AeroVironment Home EV Charging Station Receives Underwriters Laboratories Listing

AeroVironment (AV), a provider of charging solutions for every electric vehicle (EV) owner's needs, has received Underwriters Laboratories (UL) listing for its EV home charging station (EVSE-RS). The home charging station is one component of AV's complete charging solution, which includes convenience and fast charging systems for multi-unit housing, retail establishments, public locations, fleet operations, automotive dealerships, roadside assistance and options to interface with the smart grid and smart home.

Recently, AV's network of certified installers began home assessments in preparation for charging station installations for a major auto manufacturer. Installations of the home charging stations are scheduled to begin this fall.

AV's home charging station is UL listed under Subject 2594, soon to be the standard for AC power supplies and connectors for EV charging. UL 2594 addresses the certain safety and reliability aspects of AC cord sets and charge docks, up to 260 volts, critical to the deployment of EV charging infrastructure.

"With two major automakers planning to introduce plug-in electric vehicle models in November and December, the time for safe and practical charging infrastructure is now. Electric charging stations at home, work, and on the road will give drivers a broad range of convenient refueling options," said Mike Bissonette, AV senior vice president and general manager, Efficient Energy Systems business segment.

3M and Umicore Form NMC Cathode Materials Relationship

3M and Brussels-based Umicore have entered into a technology license agreement that aims at further expanding the use of Nickel-Manganese-Cobalt (NMC) cathode materials in automotive and portable consumer electronics lithium ion batteries. Under the agreement, 3M grants Umicore a license

to patents US6964828, US7078128 and equivalents in Taiwan, China, Japan, and the EU, thereby granting Umicore access to a family of NMC cathode material compositions for manufacture and sales to lithium ion battery manufacturers.

The cathode compositions composed of Nickel, Manganese and Cobalt offer an outstanding balance of power, energy, thermal stability and low cost. NMC cathode materials can be tailored through changes in composition and morphology to meet a wide range of demanding customer requirements from high energy handheld consumer electronics to high power (hybrid) electric vehicles. For large format battery applications the excellent thermal stability of NMC cathode compositions contributes to an improved battery safety performance and enables therefore a lower total battery system cost.

"We are very pleased to have reached this agreement with 3M. It will further expand Umicore's wide product offering and pave the way for NMC cathode materials in the emerging applications for lithium ion batteries in automotive market as well as further penetrate the established consumer electronics market," said Kurt Vandeputte, business line manager, UMICORE Rechargeable Battery Materials Business Line.

"NMC cathode materials have shown significant advantages in large format battery applications like electric vehicles. This agreement with Umicore will accelerate the market adaptation of the technology and enhance our ability to meet the rapidly growing needs of lithium-ion battery customers," said Chris Milker, business manager, 3M Electronics Markets Materials Division.

International Battery to Energize One of the World's Largest Hybrid Electric Sailing Yachts

International Battery has partnered with Electric Marine Propulsion (EMP) to build a hybrid power train for the world's largest plug-in, hybrid-electric sailboats, a 60 foot Tag Yachts catamaran running on wind-generated electricity stored in International Battery's lithium-ion batteries.

Christened Tang at her September 21 launching, the carbon-fiber speedster is undergoing tests at Tag facilities in St. Francis Bay, South Africa.

The main renewable energy input to the large-format battery pack is electricity regenerated by wind power as the boat's propellers spin in the wake, under sail. The propellers turn the 18-kilowatt propulsion motors, which automatically become generators and send electricity back to the batteries.

When there's not enough wind, twin 22-kilowatt diesel generators kick in automatically for recharging, together or individually as needed. The generators are 144-volt dc units that recharge the batteries directly without the normal energy loss incurred through a charger.

The batteries also can be charged with a 144-volt charger that plugs into shore power. The charger handles a wide range of voltages and frequencies, a big advantage in out-of-the way ports with erratic supplies of electricity.

Tang's hybrid system includes twin E motion 18-kilowatt permanent-magnet motors and International Battery's lithium cells configured into a 144-volt battery pack. The pack's total energy capacity is a hefty 46 kilowatt-hours. That's more than twice the usable capacity of an 8D battery pack, the largest conventional size carried with the E motion system. Yet the lithium pack weighs roughly 40 percent less.

This extra energy capacity allows the sailing yacht to offer more luxury (and power hungry) amenities to passengers including a 37 inch flat screen TV, Bose entertainment system, LED lighting, café-size espresso machine, two refrigerator-freezers, dishwasher, microwave, conventional oven, gas or electrical burner top, washer-dryer, air-conditioning and a water maker.

To keep the battery cells working at optimum levels, International Battery's battery management system (BMS) actively balances the battery cells during charge and discharge. The BMS compares each individual cell and diverts current to or from the cells to bring all cells to an equal level.

Electric Vehicles Fuelling Demand for Battery Technology and Supply

The batteries used to propel electric vehicles (EVs) can be derived from one of several chemistries, including lead acid, nickel metal hydride (NiMH) and lithium-ion (Li-Ion). The rapidly developing and evolving market for EVs is boosting demand for new battery technologies and greater supply. The EV industry has developed quickly, after decades of slow development, causing a potential bottleneck in battery technology supply. The chemical industry has recently discovered the opportunities to supply materials and components to this market, triggering a race to develop products.

New analysis from Frost & Sullivan, *Global Opportunity Analysis for Chemical and Material Suppliers in the Electric Vehicle Batteries Market*, finds that the EV Li-ion battery chemical and materials market is expected to grow at a compound annual growth rate (CAGR) of 125 percent from 2010 to 2016. The products covered in this research service are separators, anodes, cathodes, electrolytes as well as binders and casings.

"All the major automotive manufacturers are developing EVs, considered the next generation of vehicles and a means for original equipment manufacturers (OEMs) to differentiate themselves to stay ahead of the competition," said Frost & Sullivan's Global Programme Manager for Transportation Chemicals, Robert Outram. "Escalating oil prices and environmental concerns are driving governments to grant incentives and encourage zero emission vehicles, further endorsing the importance of EVs and stepping-up the demand for EV batteries."

Chemicals and materials suppliers in the EV batteries market can expect exponential growth, as major OEMs launch their EV range with a plan for commercial production.

However, only a few market participants can supply separators, electrolytes, anodes and cathodes, particularly in Europe, potentially causing a bottleneck in the entire EV batteries market. Chemical and battery companies have failed to keep pace with the development of vehicles as electric vehicles have been promised for many years. Up until recently the market has failed to materialize causing chemical companies to develop a "wait and see" attitude toward battery material development. Now the market has finally taken off, very few companies are in a position to capitalise on the opportunities.

"The market will face significant price pressure from downstream companies," said Outram. "Additionally, increasing competition from low-cost production locations will intensify the profit margin reduction for chemical suppliers."

"EV batteries need considerable improvement in terms of energy storage capacity, size, weight and cost," said Outram. "The chemical industry can help achieve these goals with the development of innovative materials, chemicals and solutions."

Ford Uses Innovative Liquid-Cooled Battery System To Help Focus Electric Owners Maximize Range

The all-new Ford Focus Electric, which debuts in the US late next year and in Europe in 2012, will be powered by an advanced lithium-ion battery that utilizes heated and cooled liquid to help maximize battery life and gas-free driving range.

Thermal management of lithium-ion battery systems is critical to the success of all-electric vehicles because extreme temperatures can affect performance, reliability, safety and durability. Ford has chosen an advanced active liquid-cooling and heating system to regulate the temperature of its lithium-ion battery packs, which are designed to operate under a range of ambient conditions.

"All-electric vehicles do not have a conventional engine on board, so it is critical we maximize the performance of the battery under various operating temperatures," said Sherif Marakby, Ford director, Electrification Program and Engineering. "Active liquid systems are more effective than air systems at regulating lithium-ion battery temperature. As a result, the active liquid system on Focus Electric will play a key role in providing our customers with the best performance possible."

The active liquid cooling and heating system also enables the Focus Electric to automatically precondition the battery pack temperature during daily recharging. When the vehicle is plugged in to the power grid, the vehicle system will be able to warm up the battery on cold days and cool it down on hot days.

While air-cooling methods work well for many of today's

smaller car battery systems, the larger, more complex lithium-ion battery technology powering Ford's all-electric vehicles calls for an aggressive thermal management system.

An active liquid system heats or chills a coolant before pumping it through the battery cooling system. This loop regulates temperature throughout the system against external conditions.

On hot days, chilled water absorbs heat from the batteries, dispersing it through a radiator before pumping it through the chiller again. On cold days, heated water warms the batteries, gradually bringing the system's temperature to a level that allows it to efficiently accept charge energy and provide enough discharge power for expected vehicle performance.

The liquid cooling system also plays a role in charging the vehicle. When the all-electric Focus is plugged in to recharge, the vehicle control system will automatically precondition the battery, if needed, to the optimal temperature before accepting charge. If the battery is already at the optimal temperature, the system will automatically accept charge and maintain an optimal temperature.

Ioxus Acquires Advanced Energy Conversion (AEC) to Deliver Full Range Ultracapacitor Cells and Modules

Ioxus, Inc., a US manufacturer of ultracapacitor technologies for military, transportation and alternative energy markets, has acquired Advanced Energy Conversion (AEC), which specializes in energy conversion systems using embedded controls, power electronics and electric machines. Ioxus will incorporate AEC products into its current offerings to deliver comprehensive, energy-efficient systems solutions for hybrid electric vehicles, wind pitch control and other energy storage applications.

"Ioxus is focused on enabling the rapid growth of energy generation and cleantech markets around the world, and the acquisition of AEC's capabilities in energy conversion systems helps us progress toward that goal," said Mark McGough, CEO of Ioxus. "The acquisition of AEC boosts our ability to quickly customize our products' design to meet the individual needs of our clients, whether they are looking for individual large cell prismatic electrochemical double layer capacitors (EDLC) or a complete system."

Index of Advertisers

Calendar of Events

November
3 - Battery Safety 2010, Boston, Mass.

4-5 - Lithium Mobile Power, Boston, Mass

January
24-28 - Advanced Automotive Battery Conference & Symposium, Pasadena, Calif.

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

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

16-18 - BATTCON, Orlando, Fla.

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

Wax, Soap Clean Up Obstacles to Better Batteries

A little wax and soap can help build electrodes for cheaper lithium ion batteries. The one-step method will allow battery developers to explore lower-priced alternatives to the lithium ion-metal oxide batteries currently on the market.

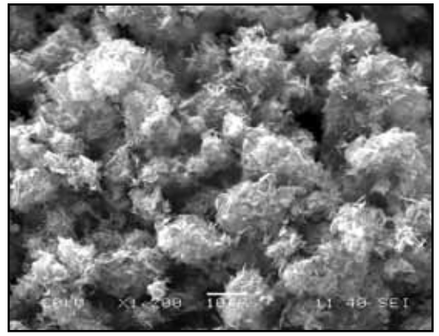
"Paraffin provides a medium in which to grow good electrode materials," said materials scientist Daiwon Choi of the Department of Energy's Pacific Northwest National Laboratory. "This method will help researchers investigate cathode materials based on cheaper transition metals such as manganese or iron."

Consumers use long-lasting rechargeable lithium ion batteries in everything from cell phones to the latest portable gadget. Some carmakers want to use them in vehicles. Most lithium ion batteries available today are designed with an oxide of metal such as cobalt, nickel or manganese. Choi and colleagues at PNNL and State University of New York at Binghamton wanted to explore both cheaper metals and the more stable phosphate in place of oxide.

Cheaper, Stabler

While cobalt oxide performs well in lithium batteries, cobalt and nickel are more expensive than manganese or iron. In addition, substituting phosphate for oxide provides a more stable structure for lithium.

Lithium iron phosphate batteries are commercially available in some power tools and solar products, but synthesis of the electrode material is complicated. Choi and colleagues wanted to develop a simple method to turn lithium metal phosphate into a good electrode.



Made with a one-step method, these flakes of lithium manganese phosphate can serve as electrodes for batteries. Photo courtesy of Pacific Northwest National Laboratory

Lithium manganese phosphate, LMP, can theoretically store some of the highest amounts of energy of the rechargeable batteries, weighing in at 171 milliAmp hours per gram of material. High storage capacity allows the batteries to be light. But other investigators working with LMP have not even been able to eek out 120 milliAmp hours per gram so far from the material they've synthesized.

Choi reasoned the 30 percent loss in capacity could be due to lithium and electrons having to battle their way through the metal oxide, a property called resistance. The less distance lithium and electrons have to travel out of the cathode, he thought, the less resistance and the more electricity could be stored. A smaller particle would decrease that distance.

But growing smaller particles requires lower temperatures. Unfortunately, lower temperatures means the metal oxide molecules fail to line up well in the crystals. Randomness is unsuitable for cathode materials, so the researchers needed a framework in which the ingredients (lithium, manganese and phosphate) could arrange themselves into neat crystals.

Wax On, Wax Off

Paraffin wax is made up of long straight molecules that don't react with much, and the long molecules might help line things up. Soap, a surfactant called oleic acid, might help the growing crystals disperse evenly.

So, Choi and colleagues mixed the electrode ingredients with melted paraffin and oleic acid and let the crystals grow as they slowly raised the temperature. By 400°C, crystals had formed and the wax and soap had boiled off. Materials scientists generally strengthen metals by subjecting them to high heat, so the team raised the temperature even more to meld the crystals into a plate.

To measure the size of the miniscule plates, the team used a transmission electron microscope in EMSL, DOE's Environmental Molecular Sciences Laboratory on the PNNL campus. Up close, tiny, thin rectangles poked every which way. The nanoplates measured about 50 nanometers thick, about a thousand times thinner than a human hair, and up to 2,000 nanometers on a side. Other analyses showed the crystal growth was suitable for electrodes.

To test LMP, the team shook the nanoplates free from one another and added a conductive carbon backing, which serves as the positive electrode. The team tested how much electricity the material could store after charging and discharging fast or slowly.

When the researchers charged the nanoplates slowly over a day and then discharged them just as slowly, the LMP mini battery held a little more than 150 milliAmp hours per gram of material, higher than other researchers had been able to attain. But when the battery was discharged fast, within an hour, that dropped to about 117, comparable to other material.

Its best performance knocked at the theoretical maximum at 168 milliAmp hours per gram, when it was slowly charged and discharged over two days. Charging and discharging in an hour, a reasonable goal for use in consumer electronics, allowed it to store a measly 54 milliAmp hours per gram.

Although this version of an LMP battery charges slower than other cathode materials, Choi said the real advantage to this work is that the easy, one-step method will let them explore a wide variety of cheap materials that have traditionally been difficult to work with in developing lithium ion rechargeable batteries.

This work was supported by PNNL and DOE's Offices of Energy Efficiency and Renewable Energy and of Electricity Delivery and Energy Reliability.

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