USABC Electric Vehicle Program - Lithium Battery Development

Lithium Batteries - Moving Toward Tomorrow's Commercial Success

Lithium-based batteries offer the most long-term potential for commercially practical full-range electric vehicles (EVs). Lithium batteries have the potential for achieving higher specific energy than lead and nickel-based technologies. Lithium based batteries are also an ideal candidate for use in hybrid vehicles (HEVs), because of their outstanding electrochemical characteristics. Baseline cell chemistries and electrode designs for the lithium ion and lithium polymer cells and modules have been developed by the United States Advanced Battery Consortium (USABC) in collaboration with the U.S. Department of Energy (DOE).

In EV designs, specific energies over 100 Wh/kg appear to be achievable, and peak specific powers in excess of 1000 W/kg have been reported for hybrid designs. Full-scale modules of lithium-based batteries for electric cars are being developed and delivered to DOE laboratories for performance and life verification testing. The engineering and manufacturing of these battery systems entails high risk, research, and development. The current coal is that commercially competitive electric vehicles based on lithium battery technology could be available by 2005.

The DOE-USABC Program Supports Lithium-Ion Development

The lithium-ion battery development, under the USABC program, has the potential for exceeding mid-term electric vehicle battery targets, with an emphasis on system safety. Lithium-ion technology builds on a large base of commercial experience in small cells for the consumer electronics market. Lithium-ion cells are based on insertion electrodes, in which lithium-ions move from the positive terminal to the negative one on charge and in the opposite direction on discharge. Both electrodes are made of insertion compounds, which accept lithium ions interstitially with little structural change to the host material. Ambient temperature lithium-ion batteries with a liquid electrolyte promise to fulfill the energy-storage requirements for traction applications in the near future. Comprehensive analyses and tests of abuse tolerance are being conducted, including hardware testing and failure modes and effects analysis.

Under the USABC program, SAFT is developing a high-energy lithium-ion cell designed to power electric vehicles. This new generation of products is highly suited to any charge/discharge cycling application that demands a battery with weight and volume drastically reduced. SAFT has developed a standard module of 6 cells, combined with an electronic control management system for the monitoring of charge and discharge voltages as well as temperature. This modular concept allows a larger battery pack to be easily customized. Potential advantages are very high specific energy, high cycle life, and low cost with proper choice of materials.

In dedicated R&D projects over the past several years, VARTA has scaled-up lithium-ion batteries to EV-size prototypes. Using lithium manganese spinel and carbon as active materials, 110 Wh and 250 Wh lithium-ion cells were developed. The cells were then integrated into modules of up to 2.5 kWh, which include the necessary thermal and electronic controls. These modules could serve as building blocks for large traction batteries.

The DOE/USABC Program Supports Lithium Polymer Development

The key to an advanced battery is to select highly energetic materials and package them into a battery using affordable materials and processes without introducing excessive packaging weight and volume. The lithium polymer battery technology does exactly this. Lithium is the lightest metal with the highest electrochemical potential. The USABC/DOE Program has supported the development of lithium polymer thin-film cells. Because the intrinsic conductivity of the polymer electrolyte material is low, individual cells are constructed of thin films about 100 micrometers thick. Many such cells must be combined for use in an electric vehicle battery. The technology relies on generating high surface areas to build the high energy and power capacities required of advanced technology batteries. A full-sized EV battery would contain several kilometers of thin, laminated electrode and electrolyte material. Each layer in the battery is produced in continuous web processes, suitable to high-speed cost-effective manufacturing. Using lithium metal as an anode provides exceptional specific energy and energy density. The use of polymer electrolytes adds packaging opportunities unavailable in liquid electrolytes.

Lithium polymer battery technology has been under development for nearly twenty years. Through 1999, a team composed of 3M, Hydro-Quebec, and the Argonne National Laboratory has conducted a unique lithium-polymer technology development program to create EV-size modules. Benefits of the lithium polymer battery technology include good thermal characteristics and abuse tolerance.

Tomorrow's Research and Development Goals

- Demonstrate the best of these technologies in full-size modules.
- Achieve 1000 charge-discharge cycles for the lithium polymer battery technology.
- Improve abuse tolerance for the lithium polymer battery technology.
- Develop thermal management systems for lithium polymer battery technology.
- Improve ionic conductivity of polymer based electrolyte materials.

Sources for Additional Information

The International Electric Vehicle Symposium, held annually in a location that rotates among North America, Europe, and Asia, is the largest technical conference devoted to electric and hybrid vehicles. It features both papers and exhibits, not only by the major auto companies but also by manufacturers of batteries, chargers, and assorted other components.

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