The lithium battery as a source of hope

March 23 2012

The future belongs to electric vehicles – the experts are convinced of this. But there are a few challenges to overcome before quietly whirring electric cars can completely replace the combustion engine. One such challenge is the power supply: batteries have to be safe, reliable and reasonably priced. Promising developments in this area include lithium cells, which offer the highest energy density. These batteries are not just used in electric cars, though – they're also in demand for the storage of wind and solar energy, for medical examinations or to propel deep-sea vehicles. Fraunhofer researchers will be on hand to demonstrate lithium batteries for a variety of applications at Hannover Messe.

If the wind is blowing or the sun is shining, renewable energy sources often deliver more power than consumers need – so a way has to be found to store surplus energy. While lithium-ion batteries can store lots of energy, they also take a long time to charge. Supercapacitors, on the other hand, can quickly store energy, but their energy density is low. Researchers at the Fraunhofer Institute for Silicate Research ISC in the Center for Applied Electrochemistry in Würzburg are now working on developing a battery that combines the benefits of lithium-ion batteries and supercapacitors. Depending on the requirements involved, the scientists intend to produce energy-storage media that they can set either to the high energy density of a battery or to the high output density of a supercapacitor. For example: lithium-ion batteries that charge many times faster than conventional batteries.

Even just a few degrees' temperature difference can make a huge difference; this law also applies to lithium batteries. Adding ten degrees

Celsius cuts the energy-storage medium's life in half. So an ingenious cooling system is indispensable. For electric-car applications, researchers at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg have developed a well-cooled battery system: the system consists of twelve flat lithium cells with a fluid-fed cooling plate on each side of each lithium cell. To get peak performance from the cooling plates, the researchers have simulated their form and tailored it to the geometry of the individual battery cells.

The effect is impressive: The cooling plates provide largely homogeneous temperature distribution in the battery module while reducing the temperature rise to just a few degrees, even under large loads. As another benefit, the scientists have attached a circuit board to each battery module to create a module-management system. The system monitors the temperature, charge and deterioration of the individual cells in the battery module and transmits the data to the battery system's central control unit. For this purpose, algorithms based on stochastic particle filters were developed with the aid of model-based processes.

Researchers at the Fraunhofer Institute for Chemical Technology ICT in Pfinztal rely on air cooling: They stack the individual lithium cells on top of one another, separated by narrow strips of special polymer foam. A fan is used to circulate the air. These strips offer two benefits: for one, they create channels in the interstices through which air can flow and heat can be drawn away. For another, with the cells lying directly atop the foam strips, the design is very stable. Cooling is optimal: the cells are no warmer than the air drawn away from them. Coolant pumps, coolant fluids and heat exchangers are superfluous. Cooling elements account for less than 20 percent of the cells' total weight – making the battery well-suited for lightweight construction in the automobile industry.

Lithium cells are usually rigid and immobile. Yet there is a demand for pliable cells in some applications, medicine being one example.

Scientists at the Fraunhofer Institute for Silicon Technology ISIT in Itzehoe have developed the first flexible lithium battery: the battery can bend and twist. But how did researchers accomplish this? "We work with very thin electrodes," Dr. Reinhard Mörtel, a scientist at ISIT, reveals. In addition, the cathode, the separator and the anode all contain between one and ten percent plastic as a bonding material. This material glues the individual particles to one another, ensuring formation of the active layers. Researchers used a laminable plastic to make the flexible cells. If the layers are warmed under slight contact pressure, they adhere very tightly to one another and will not separate even if the cell is twisted or bent. One use of the cell is for sleep-laboratory patients: because most people can sleep better at home than in a laboratory, the patients take the measuring equipment home with them. The bending lithium cell permits a supply of current without the annoying cables.

For lithium batteries to supply electricity to underwater vehicles at great depths, they must be able to withstand enormous pressure. Researchers at ISIT have come up with a battery that withstands pressures of up to 600 bar – meaning 600 times normal atmospheric pressure. These cells also offer a very high energy density. Researchers used two approaches to achieve pressure resistance: the cells they used are tension-resistant pouch cells. In pouch cells, the anode and cathode are wrapped inside a film from which all the air has been drawn out – not unlike vacuum-packed coffee.

The second approach involves the separator: the separator separates the anode and the cathode from one another to prevent short-circuiting. Usually, these separators are made of a thin layer of fiberglass that mechanical forces can easily destroy: the result is a short-circuit that can wipe out the entire battery. Researchers have now developed a ceramic-reinforced separator that offers considerably more safety. Another benefit: the separator is rollable and can easily be commercially processed.

Safety is an important criterion when it comes to batteries. With lithium batteries, the aim is to prevent short-circuiting. Short-circuits occur if the two electrodes come in contact with one another. Separator layers are designed to keep them apart. But if the lithium ions crystallize to dendrites – tree-like crystal structures of the kind found in snowflakes – these dendrites could pierce the separators. In the future, a new electrolyte will prevent short-circuiting: it contains ceramic elements. They make it more difficult for dendrites to pierce the separator. Another safety benefit: the ceramic structures are flame-proof, making it more difficult to ignite the electrolytes. Some 80 percent of all incidences of damage can be prevented through use of the new electrolyte being developed by researchers at ISC. This is particularly important for lithium batteries with very high energy densities.

Researchers at the recently opened ICT Battery Testing Center are investigating the safety of certain battery types. Are the electrolyte and battery materials compatible? What happens if the electrolyte is exposed to excessive temperatures or other difficult environmental conditions? The researchers are looking into how internal conditions such as a cell's chemical composition and layout, and external conditions such as ambient temperature, affect battery quality and battery life.

Provided by Fraunhofer-Gesellschaft

Citation: The lithium battery as a source of hope (2012, March 23) retrieved 15 August 2024 from https://phys.org/news/2012-03-lithium-battery-source.html