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Materials

Pencil-in cool temps for Li-ion batteries

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A lithium-ion polymer battery pack—with cells—is surrounded by AllCell's Phase Change Material.

Engineers at an Illinois company propose using pencil lead and paraffin to keep lithium-ion batteries from overheating in hybrid- and all-electric vehicles.

The cooling concoction, known as a Phase Change Material (PCM), belongs to **AllCell Technologies**. Formed in 2001 as an **Illinois Institute of Technology** spin-off, AllCell holds the exclusive worldwide patents on using PCM for the thermal management of any electrochemical energy storage device.

AllCell's PCM—paraffin micro-encapsulated in a graphite matrix—is currently undergoing automotive testing and validation "aimed at optimizing the cost, volume, and performance to meet customer requirements," noted Peter Sveum, a senior engineer at AllCell Technologies.

PCM helps protect Li-ion batteries from a primary foe: heat.

Li-ion batteries electrochemically degrade at a faster rate when at rest or operating at high temperatures than do cool cells. The same is true for hot spots within the battery—degradation damage occurs more quickly than it does with cooler cells.

"This reduces the life and performance of the entire battery system and puts additional strain on the electronics to keep the cells balanced. The system needs to be kept cool enough to ensure safe operation of the system or, in the worst case, deal with the heat generated by a cell failure," explained Sveum.

Conventional approaches to cooling Li-ion batteries involve blowing air or flushing liquid around the cells. "But both methods require ducting and fans or pumps, which draw energy from the battery to operate," Sveum pointed out.

PCM does not require energy from the battery to operate or a circuit to activate. Thermal management is accomplished by storing the waste heat of the Li-ion cells as latent heat during the solid-to-liquid phase change of the paraffin.

"The graphite matrix maintains the shape of our PCM even after all of the wax turns to liquid. Basic physical forces keep the wax in the graphite 'sponge.' The surface tension between the wax and graphite is much stronger than the forces that try to make the melted wax leak out," explained Sveum.

During battery discharge, some of the heat dissipates and some of the heat is stored in the PCM and the cell. When the cell stops generating heat during a rest period, the heat stored in the thermal capacitor is dissipated back into the cell and the surrounding environment. As the substance reverts to solid from liquid, the heat dissipates into the environment after temporarily being stored in the thermal capacitor, according to Sveum.

AllCell Technical Sales Engineer Gregory Albright said that the PCM's high thermal conductivity and narrow melting band creates temperature uniformity within the pack; typically the temperature spread is less than 3°C (5.4°F). "The battery pack's latent heat results in a lower peak temperature of the system," he said.

PCM can function as a stand-alone thermal management system, or it can act as a thermal capacitor "when combined with an active system to reduce the weight, volume, and operation time of active systems, like air or liquid cooling. In addition, PCM's ability to absorb shock and vibration make it an attractive packaging material for the cells," Albright said.

The notion of using PCM for thermal management is not new, but engineers found the solution was either "too messy or too heavy. Our innovative graphite matrix solves both issues," Sveum noted.

Production vehicle applications for PCM are possible as early as the 2012 model year. Other than Li-ion batteries, AllCell's PCM can be used with nickel metal-hydride batteries or with a fuel cell.

"AllCell's PCM spent years in research and development before its introduction as a product to the military and the handheld electronic device markets," noted Sveum.

He added that PCM is a composite material "that lasts thousands of thermal cycles. Current product feedback and material testing projects that PCM's lifespan will be greater than the 10-year life targets of vehicle energy storage systems."

Kami Buchholz