Researchers demonstrate a technique to fabricate safer and more compact batteries

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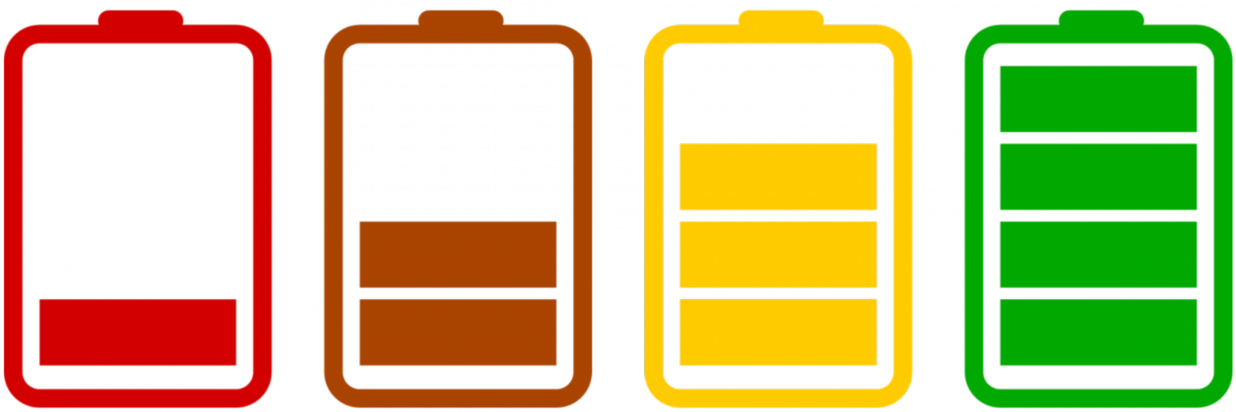

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The lithium-ion batteries that commonly power mobile phones and laptops are ubiquitous and efficient. But they can occasionally explode—as evidenced in the batteries used by Samsung's Galaxy Note 7, which the company recalled last year.

Solid-state batteries, which eschew the flammable and unstable liquid electrolytes of conventional lithium-ion batteries, could be a safer option. Now, researchers have demonstrated a new way to produce more efficient solid-state batteries. This proof-of-principle study may lead to safer and more compact batteries useful for everything from sensor networks to implantable biomedical devices.

Alex Pearse, a doctoral student at the University of Maryland, College Park and the Nanostructures for Electrical Energy Storage, a DOE-sponsored Energy Frontier Research Center, will present this work during the AVS 64th International Symposium and Exhibition being held Oct. 29-Nov. 3, 2017, in Tampa, Florida.

A battery is composed of two oppositely charged electrodes, the cathode and anode. Nestled between them is an electrolyte that allows ions to transfer from one electrode to another when the battery's circuit is completed, enabling electric current to flow. In lithium-ion batteries, this electrolyte is liquid.

Replacing a liquid electrolyte with a solid makes for an inherently more stable battery. A solid electrolyte also offers the potential for thin film construction, but these solid-state batteries, which use glass electrolytes, can't store as much energy as their liquid counterparts, a problem mainly due to the fabrication process.

To make thin-film solid-state batteries, conventional methods employ what's called line-of-sight physical vapor deposition (PVD), which is akin to spray painting. The electrodes and electrolyte are made by directly depositing the material as a film onto a surface. These films must be very thin, or else the layers can separate and break down.

"You can't make the films very thick before you get issues with cracking or delamination," Pearse said. "It takes too long to grow and gets very expensive."

But because a thin battery can't hold as much current, it can't store that much energy in a given area. Just to power your smartphone, Pearse explained, a solid-state battery would need to span one square meter.

One way to increase capacity is to introduce holes, ridges, or other patterns that boosts the surface area. But conventional PVD doesn't work for these complex, 3-D shapes.

"You can imagine a can of spray paint and aiming it at some complicated 3-D, porous object," Pearse said. "You won't be able to cover every nook and cranny with the even coat that's needed."

So Pearse and his colleagues tried another technique called atomic layer deposition (ALD). ALD bathes the object in the material—vaporized into a gas–which adheres to the entire surface. The result is a thin film that evenly blankets an object of any shape.

Although ALD is a well-established technique, this is the first time it's been used to fabricate a full, 3-D solid-state battery, Pearse said. To increase surface area, the researchers designed their battery with a series of holes, developing new patterning strategies to create precise coatings. Because the layers are still very thin, the battery can be very compact and can also be recharged quickly.

The prototype can't yet compete with conventional batteries, Pearse said, but it paves the way forward. While solid-state batteries still can't compete with most conventional ones, they may be well suited for certain applications, such as in tiny sensors. Because there are no toxic liquids that can leak, they would also be ideal for biomedical devices implanted in the body. Best of all, they are unlikely to explode.

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