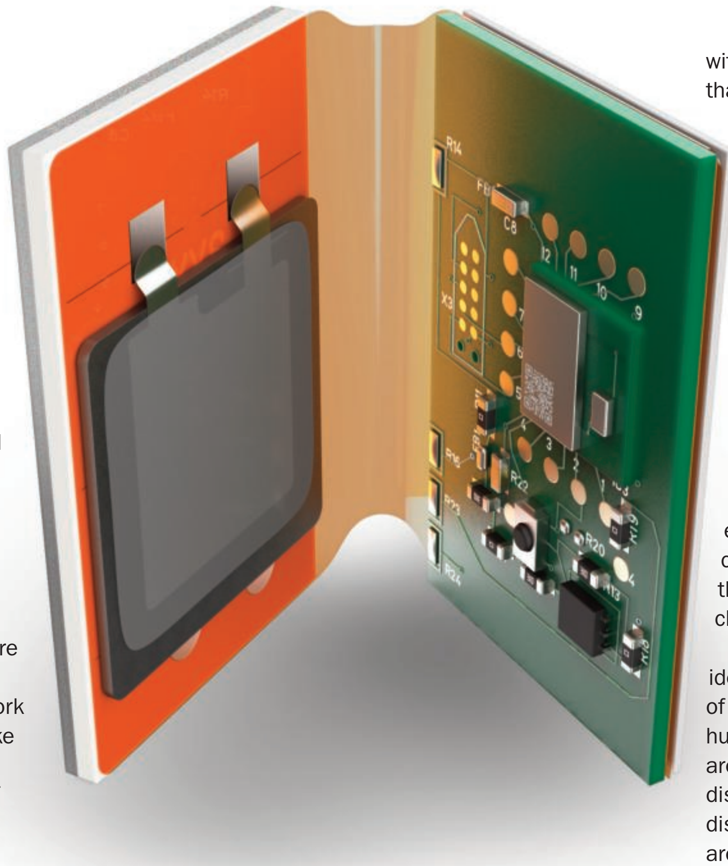
Flat batteries!

Could a 1mm thick solid state battery drive the development of the IoT? By **Graham Pitcher**.



A perpetual beacon opened to show a Stereax M250 battery (on the underside of PV panel, left) connected by a flex to a battery management system and Bluetooth LE module

Researchers have been searching for alternatives to the ubiquitous lithium-ion battery for some time. A number of reasons support the research, including the need for greater energy density, lower self discharge and longer life. A further driver for this work is safety; lithium-ion batteries can be dangerous if they get too hot or are not charged correctly.

One common factor in this research has been the quest for solid state batteries, where the liquid electrolyte found in the Li-ion cell is replaced with a solid substance. A further benefit is that because the cell doesn't hold a liquid, it can be made in shapes that wouldn't previously have been possible.

The first solid state batteries were developed at Oak Ridge National Laboratory (ORNL) in the US, but work is underway at a UK company to take the concept further.

Graeme Purdy, chief executive of Ilika – a University of Southampton spin out – said: "Most competitive solid state batteries rely on the ORNL invention, with brings together a combination of a lithium cobalt oxide cathode, a lithium phosphorous oxynitride electrolyte and a lithium metal anode.

"These work well together," he noted, "and do provide advantages. But the problem is that you can only make small cells using that approach."

Ilika has been developing materials for the automotive, aeronautical and electronics markets for more than a decade, working with global organisations including Rolls Royce and Toyota.

Ilika says it can accelerate the development of new materials for energy and electronics applications through the use of patented, high throughput techniques that enable functional materials to be made, characterised and tested up to 100 times faster than traditional techniques.

Using that approach, it has developed a micro solid state battery technology which it claims will meet the specific demands of a range of IoT applications.

According to Purdy, the company has worked with Toyota since 2008. "It wanted to use our platform to develop safer batteries for use in hybrids. It wanted to move from NiMH, which were good, but heavy, to Li-ion, but was conscious that Li-ion could catch fire.

"We have busy since then working with Toyota's R&D department and that work has resulted in a series of patents."

Essentially, Ilika's work has been aimed at developing a series of materials that could enable the creation of an intrinsically safe battery. "But we recognised these materials could also enable battery characteristics that go beyond the benefits of intrinsic safety," Purdy added. "With these batteries, about half the size of a standard Li-ion device, we have removed the poly separator and the liquid electrolyte, replacing them with a ceramic ion conductor. Not only is the battery smaller, it can also charge and discharge more rapidly."

And Ilika believes its technology is ideally suited for use in a wide range of IoT devices. "The IoT market is huge," Purdy noted. "Most sensors are currently hard wired or powered by disposable batteries. The disadvantage here is that batteries are expensive to install and then to replace.

"For IoT devices to gain wide adoption, they need to be able to be fitted, then forgotten about. Our Stereax battery technology is a key to turning this into a reality."

Stereax batteries use patented materials and processes to bring better energy density per battery footprint – up to 40% better than current solid state solutions – and the ability to work at temperatures of 100°C and higher.

"Where electric vehicles need to store about 80Ahr," Purdy continued, "microbatteries only store around a few hundred µAhr and are a good fit with our capability. And we have a pilot manufacturing line which can produce prototypes to demonstrate the advantages."

In Purdy's view, the most important parameter is capacity – how much power you can store per unit area. "But another question is whether cells can be stacked," he continued. "Not only does our material bring a 40% improvement in capacity, it also enables cells to be stacked."

That last ability is lacking in solutions based on the ORNL technology, Purdy explained. "The disadvantage of that approach is the need to package cells because the processing temperature of lithium cobalt oxide is higher than the melting point of lithium. Once you've made the first stack, further processing will denature the cells underneath."

Stereax batteries are created using a semiconductor deposition process. "Our approach not only allows multiple layers of cells to be processed at the same time, it also gives designers the choice of connecting cells in parallel for more capacity or in series for higher voltage."

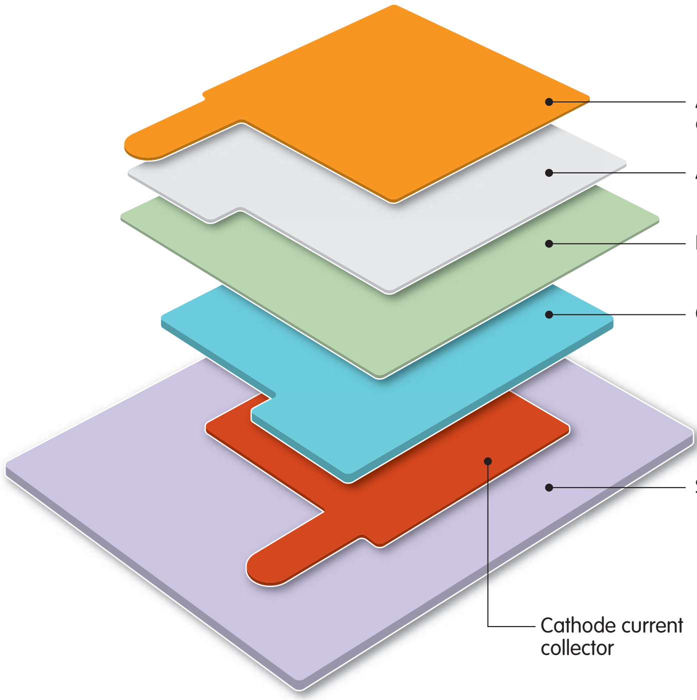
Purdy said normal cells would use a carbon anode. "But you can't do that in a solid state battery; the approach has to be more structured. Our first cells have silicon anodes and we can use this approach because our architecture allows an excess of silicon to be put down without affecting volumetric efficiency too much. It's a very useful material."

A further benefit of Ilika's approach is that batteries can be scaled to suit the application. "Our process scales in much the same way that vacuum deposition materials have been used on large areas; photovoltaics, for example," Purdy said.

A single cell, fully encapsulated, is typically about 1mm thick, but the footprint depends on the application. "Some potential customers are looking for batteries with a footprint of 1mm2," Purdy observed. "But other applications may be looking for something more like 1cm2. Our process allows cells to be etched to fit the desired footprint."

Looking to demonstrate the potential of its solid state battery technology, Ilika has created the concept of a perpetual beacon. "It combines energy harvesting with a solid state battery," Purdy explained. "A solar cell provides enough power to trickle charge the battery, maintaining enough energy to enable data to be transmitted using a low power radio protocol.

"If your energy harvester and your battery are good enough, it's possible for them to operate on an autonomous basis and for them to last as long as other components survive."



Expanded view of the Stereax M250 battery

Ilika's Stereax M250 battery technology in a perpetual beacon demonstrator.

But this concept won't work with 'any old battery'. "Current batteries have high leakage," he pointed out, "and a small PV panel won't make an impact on this. So the battery will need to offer a robust storage structure to hold charge. Not only that, but the battery needs to last at least 10 years and to be slim enough to enable sensors to be located anywhere."

While the IoT is the immediate target, Ilika has a road map which also includes wearables and automotive applications. "We're also interested in PV integration," Purdy said. "What's interesting for wearables is that designers can choose the form factor they need."

In the automotive sector, Purdy believes Ilika can help to simplify wiring looms. "There is a lot of interest in trying to disconnect sensors that are currently hard wired."

Ilika won't be making batteries, however; its business model is based on licensing and royalties. "We believe products featuring our battery technology will begin to appear in two or three years," Purdy concluded, "when OEMs get up and running with the concept."