PEERING INTO BATTERIES FOR A RECHARGEABLE FUTURE

A SPECIAL ULTRASONIC SCANNER CAN MONITOR the internal changes in lithium-ion batteries to diagnose their health.

▲ **The signal patterns of ultrasonic sound waves can be analysed for internal changes in lithium-ion battery cells.**

Rechargeable lithium-ion batteries are the bedrock of today's tech-driven society. They underpin everything from smartphones and electric vehicles, to even our homes. To take us into a greener future, batteries need to last longer, charge more quickly, and be 100% safe.

"Batteries may degrade with use over time, due to electrolyte-related internal defects. Therefore, they need to be regularly inspected," says Zhe Deng, a materials scientist at the Huazhong University of Science and Technology in Wuhan, China. "But doing so is tricky, because lithium-ion batteries are a complex closed system, which makes it difficult to obtain internal information without destroying them."

Prising apart a battery isn't feasible, because its components are often highly sensitive to air. Conventional imaging techniques, such as X-ray analysis and neutron diffraction, aren't always sensitive, quick, or convenient enough. "Better monitoring techniques are needed for battery research and development, production, use and recycling," says Deng.

In 2019, Deng and his team devised an ultrasonic imaging technique for monitoring battery health and performance. They invented an ultrasonic scanner, which involves a transducer emitting a focussed beam, with a diameter of less than 1 mm, of high-frequency ultrasound waves through a battery cell, and another transducer receiving the beam on the other side. The signal patterns detected are then analysed for abnormalities in the battery. "This is similar to how doctors keep track of a baby's health in utero or how welders scan work for defects," explains Deng.

The resulting sonograms, as Deng's team discovered[1], can provide remarkable insights into a battery's internal changes. Ultrasonic sound waves are blocked and become attenuated if, for instance, the cell in question contains gas bubbles — which occurs when a battery overheats or its cathode undergoes side reactions, among other causes.

A similar thing happens with 'unwetting,' when a battery ages and swells beyond its normal size to the extent that there is no longer enough electrolyte to completely fill the expanded pore space in the battery.

"The full infiltration of electrolyte is important to the performance of lithium-ion batteries. The ultrasonic battery scanning equipment is useful for identifying this," explains John Goodenough, a 2019 Nobel Prize laureate in chemistry, based at the University of Texas at Austin, whose work led to the invention of the rechargeable lithium-ion battery. Deng has sent one of the scanners to use in his lab.

"This technique is very useful for Li-ion pouch and prismatic cell manufacturers", says Jeff Dahn, another pioneering lithium-ion battery researcher at Dalhousie University, who is also the NSERC/Tesla Canada Industrial Research Chair. His lab has been using the scanner for more than two years, studying electrolyte unwetting caused by electrode expansion.

"It's always very difficult to tell when cells are properly wetted with electrolyte, but the ultrasonic scanner can do this non-destructively. It is also very useful to determine failure mechanisms," he says. The scanner can also identify electrolyte dry-out, and cracks during charge and discharge.

Deng and his team have expanded use of the scanner to the high-speed inspection of new batteries on industrial production lines for quality control. They count CATL, General Motors, Huawei, and BYD, among their many collaborators. In early 2022, Deng started a company, Wuxi Topsound Technology, to further commercialize the scanner.

"The scanning speed has been increased to about 10 cells per minute. We also hope one day our technique will be able to monitor the status of battery cells in electric vehicles and energy storage power stations in real time," says Deng. ■

REFERENCE

1. Deng, Z, *et al. Joule* **4**: 2017-2029 (2020)