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X-Ray CT Scanning and Battery Technology

Visualizing Quality and Safety

Next-generation energy storage technologies, such as lithium-ion batteries, are changing the landscape of just about every major industry – from advanced aerospace applications to everyday consumer products. With the major advantage storing very high energy densities while remaining small in both size and weight, lithium-ion batteries are becoming more and more prevalent in electronic devices. These batteries function differently than their predecessors and can be susceptible to different kinds of failure modes, including the very well-publicized "thermal runaway", which has plagued even the largest aerospace programs and some of the most well-known consumer brands.

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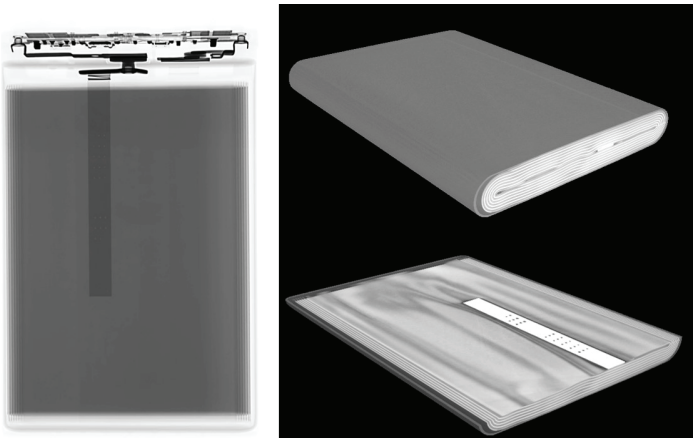
Understanding the results of battery testing and failure analysis is key to improving design and ensuring the proper functioning of internal safety features. X-ray Computed Tomography (CT) scanning has proven to be an excellent method to obtain internal, three-dimensional data in a non-destructive manner. Industrial CT scanning has been used in the analysis of batteries for several years now, including some very high-profile investigations by the National Transportation Safety Board (NSTB). The images and data captured using Chesapeake Testing's state-of-the-art CT scanning equipment were included in several NTSB reports.



Two-dimensional digital x-ray radiograph (left) and 3D cross sections (right) from a CT scan of a common lithium ion battery design found in many cellphones and other mobile devices.

The industrial CT scanning process is very similar to a medical CAT scan, which uses high-resolution radiographic data captured at multiple angles around a part. Because the objects under test are inanimate and the operators are well-protected from any radiation, industrial techniques typically include higher x-ray energies and longer acquisition times in order to maximize resolution and quality on more dense, metallic components. This process has been accessible to research scientists for decades now, but only recently has it become more cost-effective, thanks in large part to advances in digital x-ray imaging and computer processing. This means that scanning and processing techniques that previouly took hours or days, are now completed within minutes.

Much of the recent work including CT scanning of batteries often comes from the need to better understand and control the quality of consumer-grade battery cells. Issues span many types of everyday electronic devices from laptops and mobile phones, to popular motorized scooters and even e-cigarettes. Being able to obtain these internal images non-destructively creates many opportunities for improved quality control and failure analysis techniques. Data can be collected at different stages of charging or after certain types of destructive testing, such as extreme temperature, shock and vibration, and even ballistic and cell puncture testing. When it comes to analysis and high-level investigations involving suspected battery failures, one additional advantage of utilizing CT scanning is evidence preservation.

X-Ray Computed Tomography (CT) Scanning & Battery Cells
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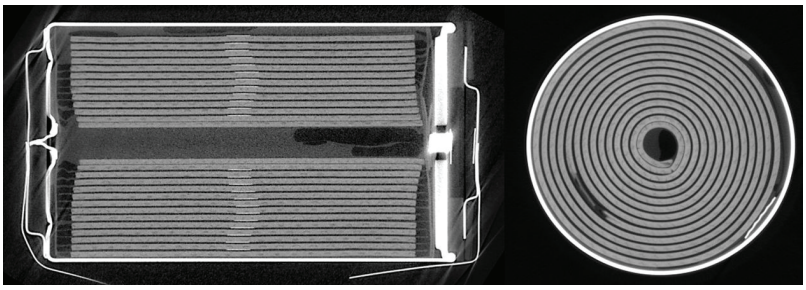
In addition to performing inspection and analysis for its clients, Chesapeake Testing has been exploring techniques for optimizing x-ray and CT scanning to better analyze battery cell structure and damage. This includes investigating methods to increase resolution and lower the noise caused by x-ray scatter, which can be detrimental to detailed image analysis, especially within larger cell designs. Academic research also continues into better imaging processes to detect and analyze failures, including in-situ, or real-time, imaging. Just last year, researchers at European Synchrotron Radiation Facility, led by University College London, performed high-speed radiographic and CT imaging of battery cells while under thermal runaway. Their results include some extraordinary images and videos taken from the data and can be found here: http://www.nature.com/articles/ncomms7924.



Two-dimensional image cross sections taken from a CT scan of a small cylindrical battery cell showing the internal structure of the layers (often called the "jelly roll") and even the gel polymer electrolyte.

As echoed in the media and amongst industry experts, there is a pressing need to improve the quality and safety of these devices. Technologies such as x-ray computed tomography are providing engineers and researchers with the information needed to more effectively analyze failures and ultimately improve battery cell design. Even with all of the negative attention surrounding lithium-ion batteries, if manufactured correctly, there are still so many benefits. There can be little doubt that these battery technologies will continue to drive new advances in energy storage and be implemented in every facet of modern life.

CT Scanning Services at NTS

NTS Chesapeake Testing division operates one of the most powerful, high-resolution x-ray CT scanning systems in use today. A large walk-in 450kV micro-focus system enables large objects (up to 37 inches in diameter) to be imaged with extremely high resolution. This system, combined with Chesapeake Testing and NTS's other testing capabilities and state-of-the-art processing and visualization tools, allows this technology to solve numerous problems spanning many different industries.

About NTS

National Technical Systems (NTS) provides test, inspection and certification services to help clients build better, stronger, safer, more reliable products and bring those products to market quickly and efficiently. NTS engineers and technicians have extensive knowledge of current test and conformity requirements, both domestic and international over a range of industries including aerospace, defense, telecom and energy.

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