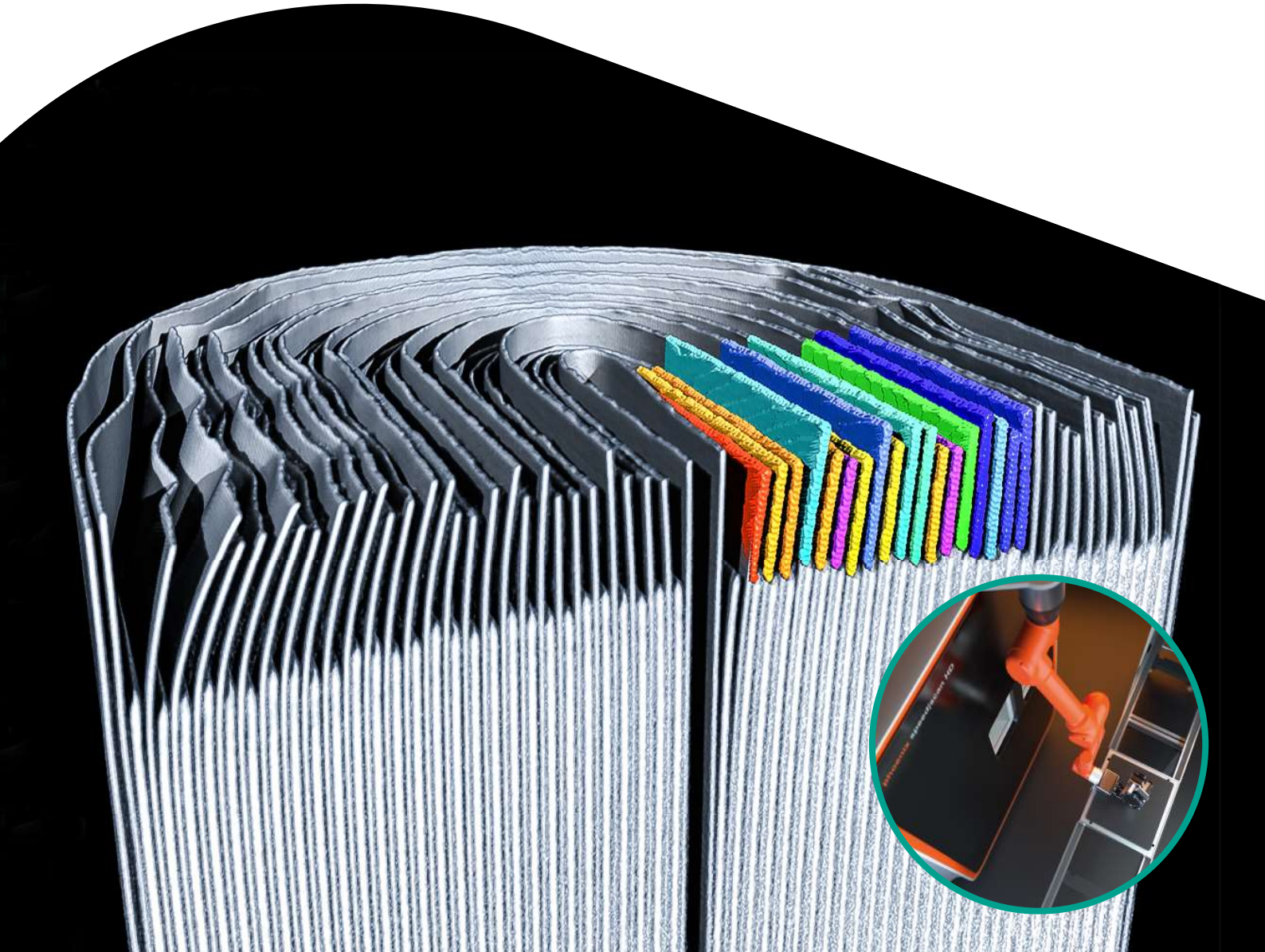
Waygate Technologies
a Baker Hughes business

Industrial CT inspection of Li-ion and Solid-state Batteries

in Laboratory & Production



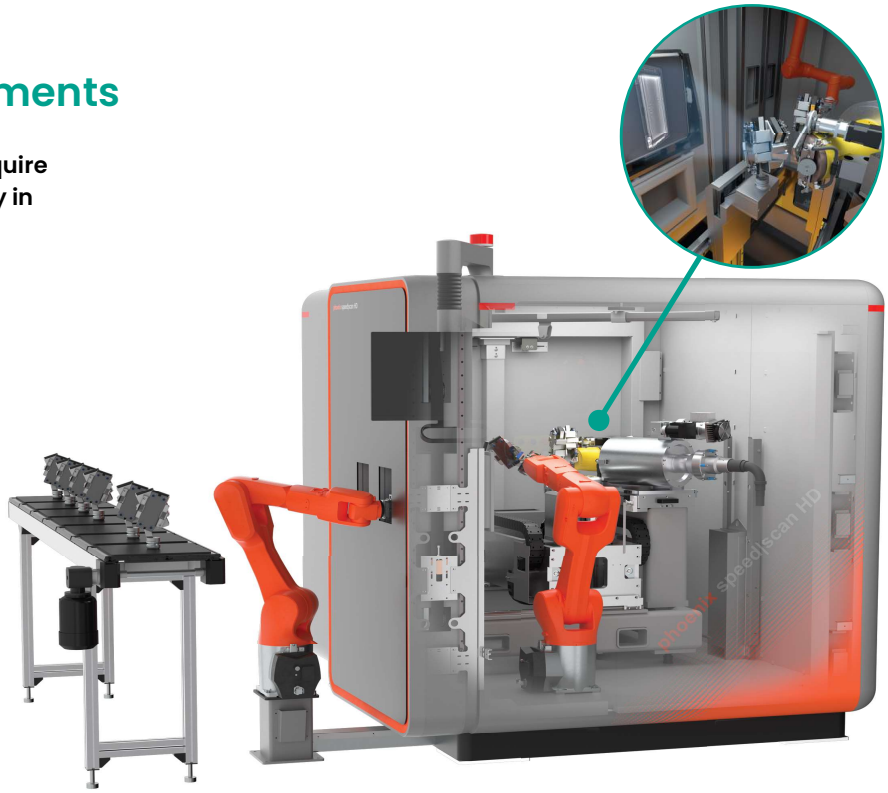
Need for Lithium-ion Battery Inspection Solutions

Demand for batteries is steadily growing and with it the demands on even faster development cycles combined with product safety and quality. Highly flexible and accurate testing and inspection of prototype batteries as well as the full scale production of batteries with industrial X-ray CT solutions is required.

Battery Industry Requirements

Key stakeholders in the battery industry require detailed product cell/module/pack visibility in different stages of the product life cycle:

- Electrode/cell/module development – prototype analytics, verification of design changes, before/after test comparison, assembly quality control
- Production quality – statistical product quality control in manufacturing process, verification of design, product and process changes
- Testing of used, damaged and/or refurbished batteries for failure analysis
- Optical or X-ray navigation map for overview of large size samples and fast positioning



Designed for fully automated battery mass inspection with microfocus technology: the Phoenix Speed|scan HD CT scanner from Waygate Technolologies.

Our Phoenix Product Line: Leading CT Solutions

On demand Inspection Services

- **CT Inspection Services pay-per-scan in major Customer Solutions Centers in Asia, Europe and North America**

Specialized Battery Laboratory Testing Equipment

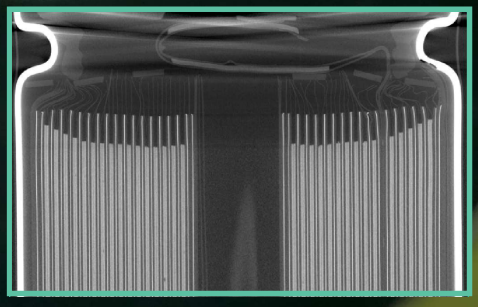
- **High accurate micro- and nanoCT for electrode & cell testing & analytics – Nanotom M, V|tome|x S, V|tome|x M, Speed|scan HD**
- **Battery module analytics – V|tome|x M, V|tome|x L300 & 450, V|tome|x C450, Speed|scan CT64**
- **Battery pack evaluations – Power|scan HE**

Production Quality Solutions

- **At-line production CT solutions with automated defect setection software for quality testing**
- **In-line production CT solutions customized for battery manufacturers needs – Speed|scan HD and CT64**

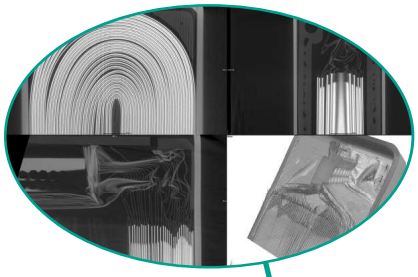
Featured Products & Accuracy

- **Battery electrode & cell lab equipment feature resolution range: 1-50 µm Voxel**
- **Module testing feature resolution range: 50-150 µm Voxel, ~300 with Speed|scan CT64**



Top part of a 18650 cylindrical cell, scanned with 5 microns voxel size in a Phoenix V|tome|x M300

Battery Manufacturing – Where and How CT can Add Value?



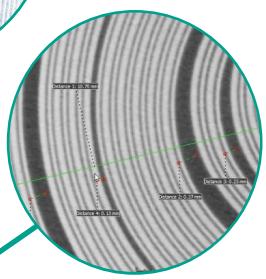
Virtual Slicing in any Direction.

Deviations can be identified and analyzed with respect to size and positioning

Deviations in Anode Overhang

Evaluate anode anomalies to optimize quality and your production processes

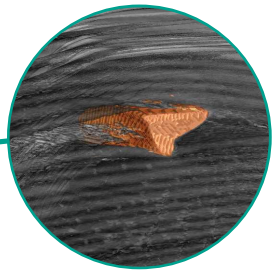
Semitransparent prismatic cell CT volume overview with visible foreign particles



Delaminations

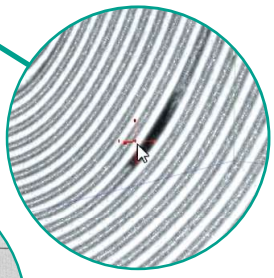
Detect and evaluate delamination areas in your cell

For the CT scan, the battery is rotated in the X-ray beam



Foreign Particles

Identify inclusions and their exact position within the battery

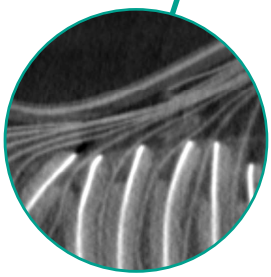


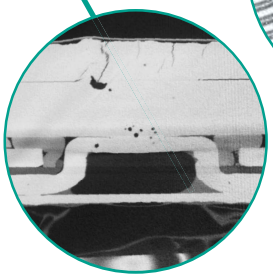
Electrode Defects

Evaluate structural electrode defects affecting the cell performance

Tab Defects

Detect disconnect, folding and wearing areas to prevent overheating zones





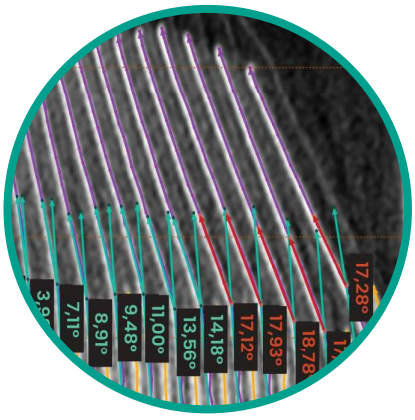
Pole Area Defects

Detect cracks in the pole shoe, pores in the casting or residual electrolyte

Artificial Intelligence powering Automated Defect Recognition (ADR)

Proprietary machine learning (ML) based algorithms deliver exceptional Automated Defect Recognition (ADR) across various flaws for e.g. battery anode overhang analysis or typical casting defects. Our AI and data science based ADR library yields greater accuracy and enhanced ease of use compared to conventional ADR approaches, eliminating the need for expert parameterization skills.

Waygate Technologies offers X|approver, the next level and premium ADR platform consisting of the full and intuitive workflow management as well as a comprehensive ADR library running in the background of your production - delivering automatic decision making. On top of it, reporting functions are provided to see potential negative trends in production at a glance. Any operator can parametrize scanned samples (e.g. for highly accurate overhang issue detection), and the algorithms get more accurate over time.



Automated anode bending measurement

CT Solutions Detect main Failure Cases and Manufacturing Defects for Cells & Modules:

- Electrode structure
- Electrode geometry "overhang"
- Foreign body material on electrodes
  - > Foreign material from mixer
  - > Electrode material from assembly
  - > Dust and abrasion
- Homogeneity of active electrode material
- Welding defects and fragments
- Burr formation
- Gas bubbles
- Dimensional accuracy of housings
- Electrolyte level
- Resin fillingmeasurement
- Resin filling status
- Tab defects:
  - > Disconnect
  - > Folding
  - > Tearing

The Full Range of Battery CT Inspection Solutions

Applications	X|cube	Microme|x Neo	Nanotom M	V|tome|x S240	V|tome|x M300	V|tome|x C450	V|tome|x L300	V|tome|x L450	Speed|scan HD	Speed|scan CT 64	Power|scan HE
2D X-ray Inspection		●		●			●	●			
Battery cells CT		●	●	●	●	●	●	●	●		
Battery modules CT	●			●	●	●	●	●		●	●
Battery packs CT											●
At-line / in-line CT					●	●			●	●	

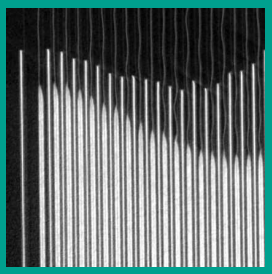
Phoenix CT for Battery Inspection - Your Advantages

- Non-destructive and 3D analysis – faster and more accurate results compared to conventional destructive laboratory methods reaction times
- Allows to visualize and analyze structure and geometry in 3D with one scan
- Adaptable solutions for existing and new battery and manufacturing technologies
- Adaptable solutions from OEM to different battery cell & module sizes
- In lab and on production floor – even in same production line
- Holistic digital data about production quality for fast process optimization and significant shorter ramp-up times
- Future-proof inspection technolgy applicable for all actual kinds auf Li-ion, but also future solid-state battery types

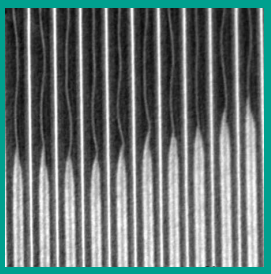
Microfocus or Nanofocus?

Jellyroll for prismatic cell scanned with:

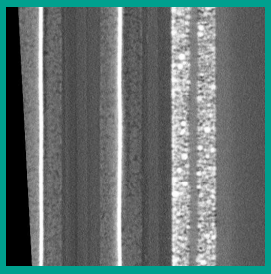
Microfocus at
20 µm/vx resolution



Microfocus at
10 µm/vx resolution



Nanofocus at
0.85 µm/vx resolution



For more detailed information or to request a demo, please visit our website or contact us.

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3D prismatic cell visualizations by Volume Graphics

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