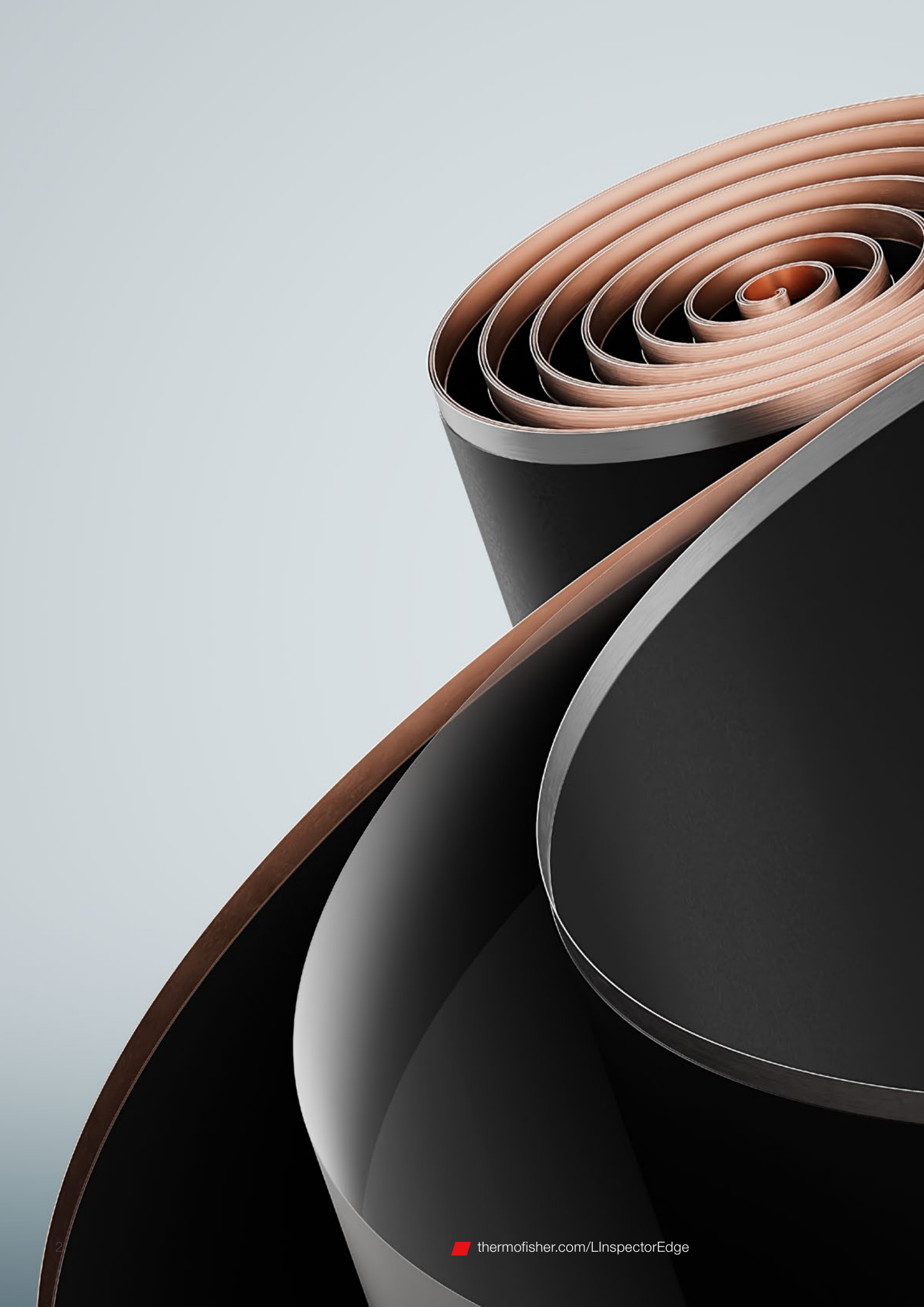


Battery solutions

LInspector Edge In-line Mass Profilometer

Electrode loading analysis – reimagined





Clean energy: Is battery manufacturing QA up to speed?

Better energy storage through better batteries, hold the key to society's transition to clean energy.

Nowhere is this more immediately obvious than in the accelerating switch to electric vehicles (EVs) which brings unprecedented demand for batteries that are:

- Safer
- More reliable
- Faster to charge
- Longer lasting
- More powerful
- Lower cost

Electrode loading uniformity, the even distribution of the active materials in the coating, is a performance-defining attribute for batteries and improvements are critical to meet these demands. Uneven coating application, unbalanced cathode and anode mass loadings, and defects impact key characteristics such as charge density, recharge time, operational lifetime, and reliability and may lead directly to safety concerns.

Catching non-uniformity and defects such as blisters, pinholes, folds, and streaks early is the key to taking cost-efficient remedial action, but with current quality measures that's not possible. Too often an electrode is only fully evaluated when the final cell

is assembled. If a sub-standard cell reaches a vehicle, then the impact can be severe – reputational damage and, in the worst case catastrophic thermal runaway and fire. Failure in the field is damaging, expensive and potentially dangerous.

To reach new levels of performance, battery manufacturers are innovating, for example, with new cathode and anode materials, while at the same time working to improve cost-efficiency. Effective, real-time quality assurance provides a foundation for improvement. Better solutions are required to:

- Detect increasingly small non-uniformities and dimensional errors
- Allow battery manufacturers to reliably balance anode and cathode mass loadings
- Identify problems more quickly to reduce waste and minimize downtime
- Provide complete traceability and assurance
- Enable responsive, advanced process control.

Current technology for electrode mass loading measurement cannot deliver these requirements. New solutions are needed.

See the whole picture

A new level of confidence and traceability

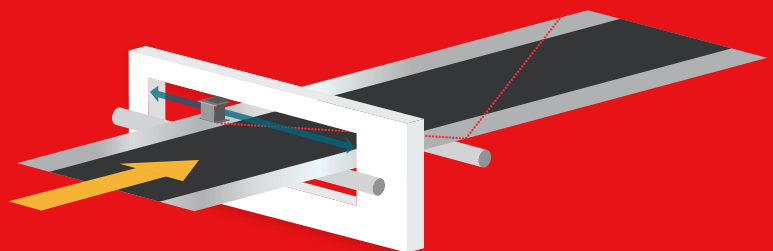
The Thermo Scientific™ LInspector™ Edge In-line Mass Profilometer provides real-time, full width electrode coating analysis, using a new, advanced technique: In-line Mass Profilometry.

Developed specifically for the battery industry, in-line mass profilometry simultaneously monitors the entire width of the electrode, measuring complete edge-to-edge coating profiles in milliseconds. The LInspector Edge In-line Mass Profilometer leverages our heritage in real-time metrology and this innovative technique to break new ground in measurement speed, precision, resolution and coverage. It allows manufacturers to confidently detect even small defects and maintain exceptional coating uniformity enabling better process understanding and accelerating new battery technologies to market.



Technology comparison

Traditional in-line gauges measure cross-width electrode profile using a single point scanning sensor. Typically, just 2 to 3% of the total surface area is measured and several meters of electrode are produced in the time it takes to complete a single profile scan.





The LInspector Edge In-line Mass Profilometer, at a glance:

- Full width basis weight and profile uniformity analysis in one system
- Orders of magnitude – 1000X – more mass loading data than conventional gauges. Complete high-resolution coating images in place of spot measurements
- Excellent spatial resolution for superior mass loading defect detection

The LInspector Edge In-line Mass Profilometer sets new standards for electrode coating analysis, measuring faster, more completely and more precisely than any other in-line technology.

The world's first profilometer that can measure 100% of the electrode coating surface.



The LInspector Edge In-line Mass Profilometer is different. It delivers precise, complete, edge-to-edge electrode coating analysis in milliseconds with no scanning.

Faster feedback, complete control

Better quality product, improved process efficiency

The breakthrough performance of the LInspector Edge In-line Mass Profilometer brings significant value by allowing manufacturers to:

Improve defect detection:

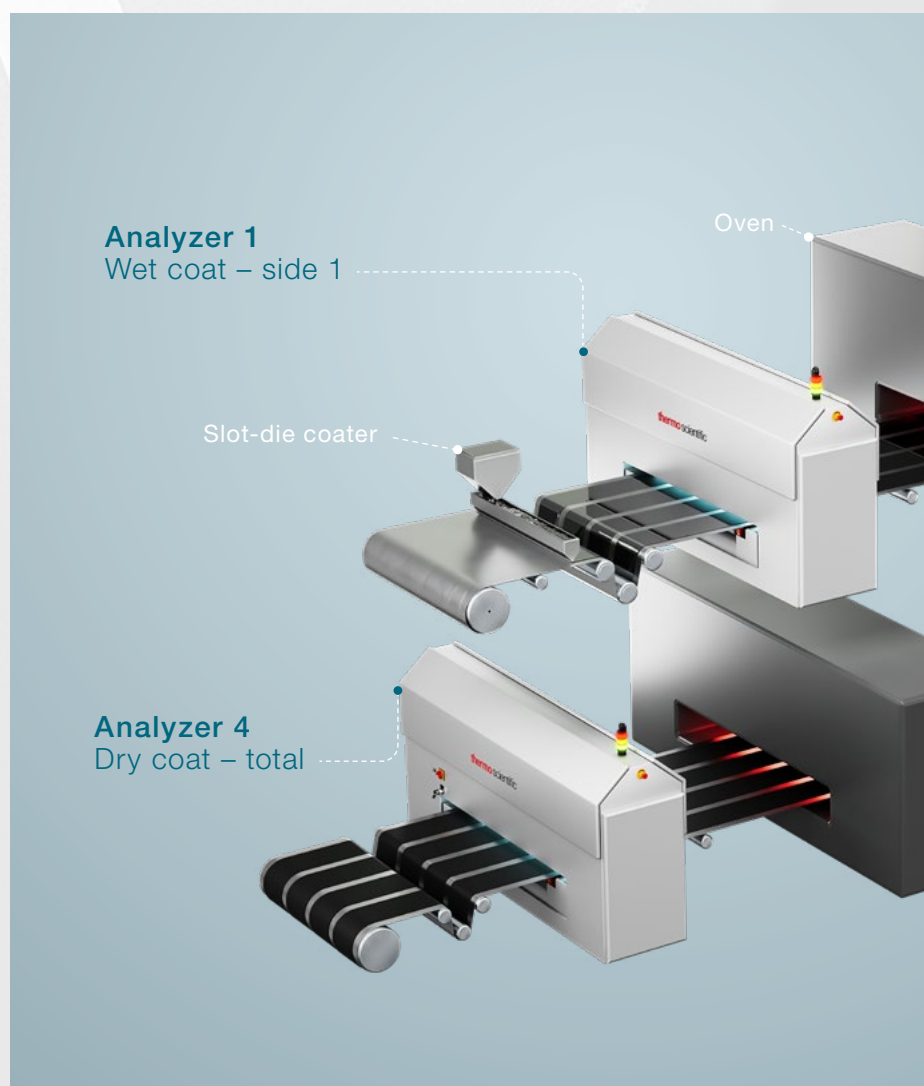
Edge-to-edge measurement, 100% area coverage and high data acquisition rates mean rapid, comprehensive, and early defect detection. Use information-rich data, complete with high resolution visualization to catch small defects – wrinkles, thick edges (“bunny ears”) and streaks – early in the process in time for effective remedial action.

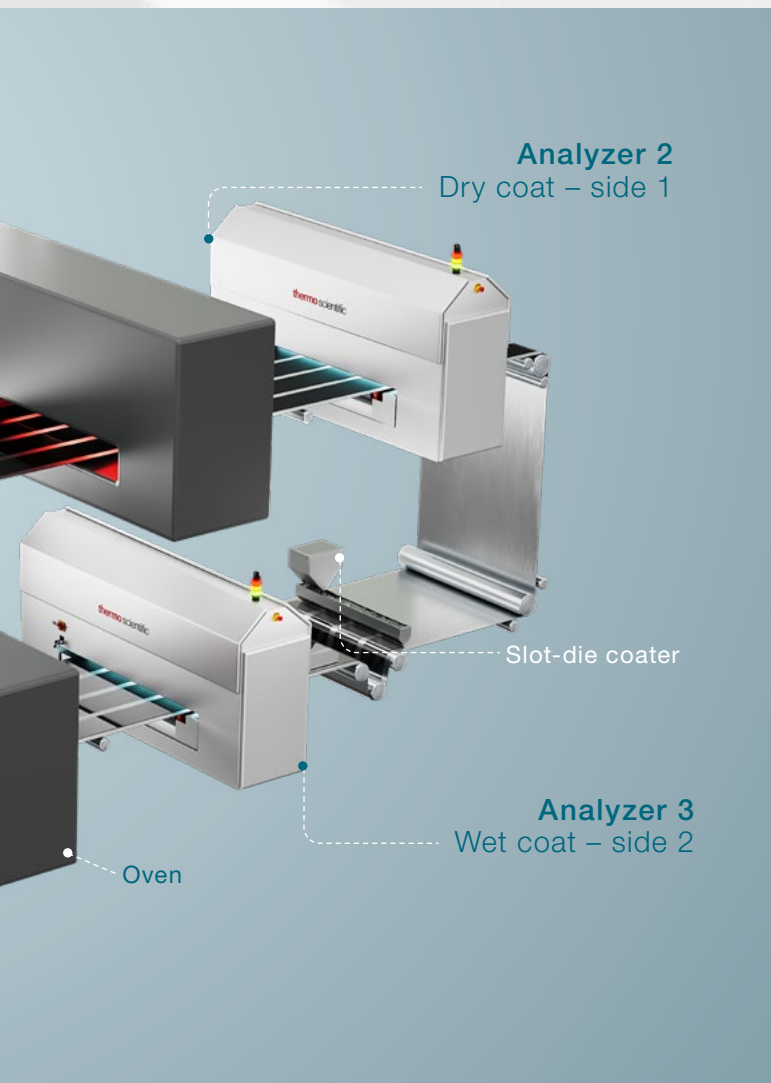
Increase production yields:

Faster feedback means quicker, better-informed, and more accurate control decisions. Start-up more swiftly and accelerate product transitions to reduce scrap and increase throughput.

Achieve full traceability:

Complete coating uniformity measurements for the entire production run, in the form of easily accessible, high-resolution images, making full traceability of an entire electrode roll finally possible. Record data for every patch or stripe, over the entire electrode surface. Export measurements and statistics to the Manufacturing Execution System to maximize visibility and drive optimization.





The heat map provides high-resolution visualization of electrode loading and coating weight defects in real-time, while the stripe profile display provides a cross section view with statistics for each stripe. Real-time availability of information-rich data allows operators to make process control decisions faster, and ensure that optimal electrode loading uniformity and coat weight are maintained.

The LInspector Edge In-line Mass Profilometer provides the data that battery manufacturers need for success, to make safer, higher performance batteries, confidently and cost-efficiently.

An investment for the future

Quantifiable difference and a real return-on-investment

To quantify the potential impact of the LInspector Edge In-Line Mass Profilometer, let's compare the performance with traditional measurement technology.

Criteria	Scanning gauge	Vision inspection systems	LInspector Edge In-line Mass Profilometer
Measured area coverage	2 – 3%	100%	100%
Mass loading measurement [gsm]	Yes	No	Yes (entire electrode)
Loading uniformity profile	Yes	No	Yes (entire electrode)
Defect detection	Limited to measured area	Optical surface only	Mass loading variations (entire electrode)
Measurement frequency	3 – 5 seconds	10 – 1000s frames per second (fps)	1 millisecond
Data visualization	Profile	Image	Image (heat map)

These gains enhance our collective ability to monitor, understand and control electrode coating processes. The associated operational savings deliver a return on investment in the form of:

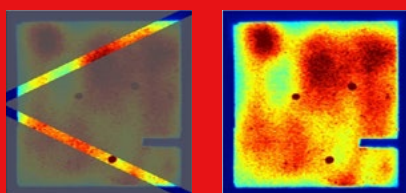
- **Reduced start-up/transition times:** With millisecond data acquisition product target setpoints can be quickly reached, making more sellable product.
- **Less scrap:** The longer it takes to detect out-of-specification product, the more scrap is produced. With faster feedback, scrap can be reduced to an absolute minimum. This is a double win – lower disposal or recycling costs and higher throughput.
- **Increased line speeds:** When operation is well-controlled, coating line throughput can be pushed to the maximum. Even small gains in speed can have a major impact on the bottom line and come at no additional cost.

All these gains can be substantial and can easily justify an investment. However, equally important are the benefits that come from reliable, timely quality assurance.

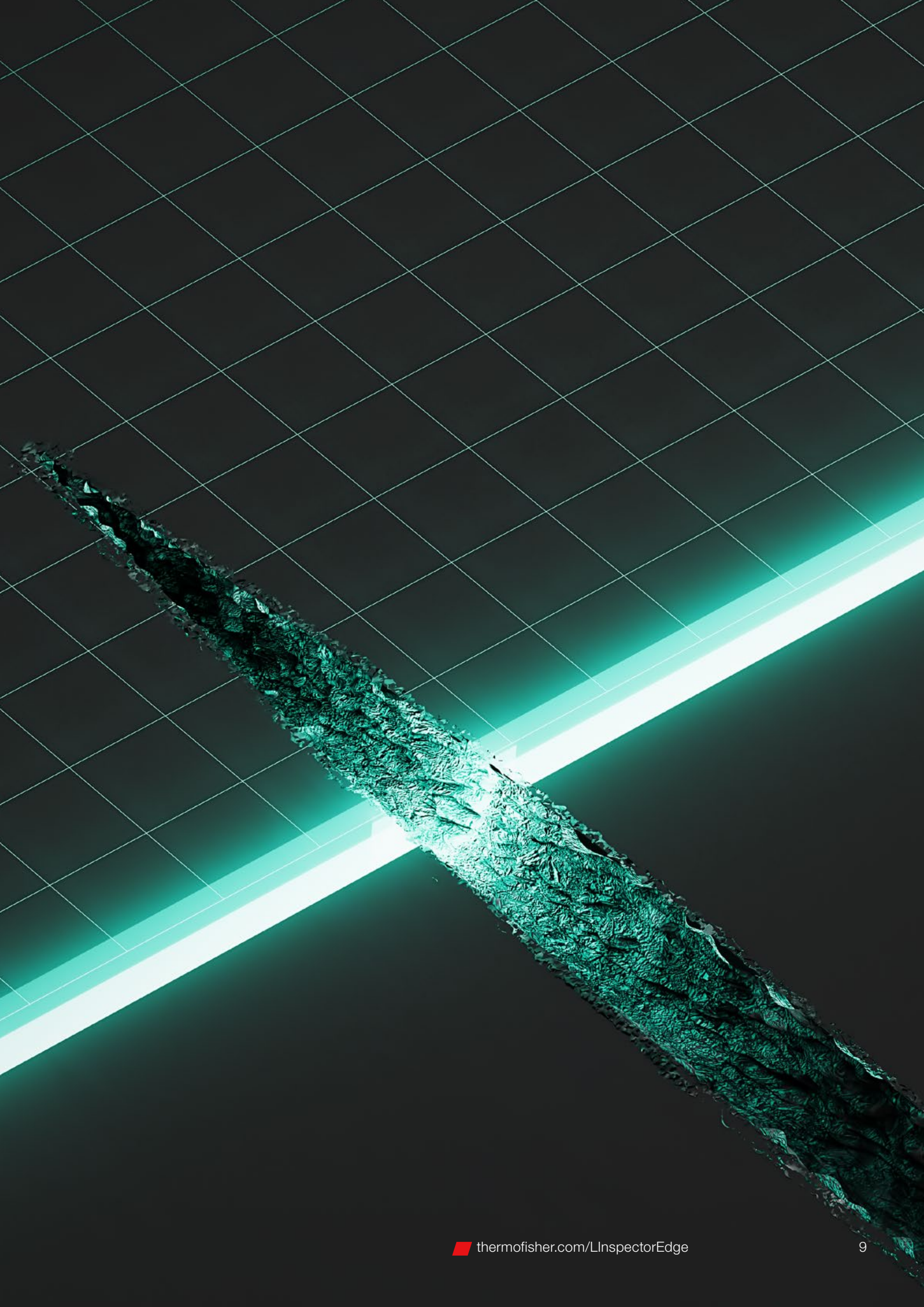
Using the LInspector Edge In-line Mass Profilometer:

- Reduces reliance on end-of-line testing.
- Decreases the risk of sub-standard electrodes slipping into the finished cell
- Minimizes the risk of producing poor quality battery packs.

Factor in the cost of just one significant safety issue, one product recall, one brand damaging event to really set an investment in the LInspector Edge In-line Mass Profilometer in context.



In these images, a small section has flaked off this coated sample. The traditional gauge (left) misses the defect because of its zig zag scanning pattern; LInspector Edge In-line Mass Profilometer clearly captures it (right).



thermo scientific



A complete package for long-term profitability

Maximum uptime with minimum effort

The inherently robust, state-of-the-art design of the LInspector Edge In-line Mass Profilometer gives it a head start when it comes to performance, reliability, and serviceability. However, customer benefits go well beyond the product itself, extending to comprehensive service plans designed to fit specific operational strategies. We offer partnership around proactive services designed to optimize operations throughout the lifetime of the equipment, thereby maximizing return on investment.

Regardless of the service plan level you choose, all customers benefit from:

- Secure global supply chains for competitively priced, high-quality spares and upgrades
- A worldwide team of engineers to provide expert support and responsive service from project initiation through commissioning, and for the lifetime of the product via tailored service contracts
- Remote technical support team, ready to answer any questions and share their expertise
- Detailed, relevant application support tailored to the needs of the battery industry
- Education and training programs to keep growing teams at peak performance

LInspector Edge In-line Mass Profilometer, a future-proof, economically sound solution to the problems facing battery manufacturers today.

 Learn more at thermofisher.com/LInspectorEdge