From Eye to Insight

Leica
MICROSYSTEMS

ELECTRIC VEHICLE PRODUCTION MICROSCOPE SOLUTIONS

OVERVIEW

In an era of carbon neutrality, electric vehicles (EVs) can help optimize energy use in the field of transportation, reduce the consumption of petrochemicals, and minimize carbon emissions. Thus, EVs have entered a period of rapid development.

With the continuous innovation needed for better battery and energy storage technology, the entire EV-industry suppy chain requires high-precision intelligent microscope solutions for efficient inspection, quality control (QC), failure analysis, and research and development (R&D).

Leica Microsystems provides complete solutions for sample preparation and microscopic analysis that help EV manufacturers meet their needs.

Power Electronics Controller
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Battery
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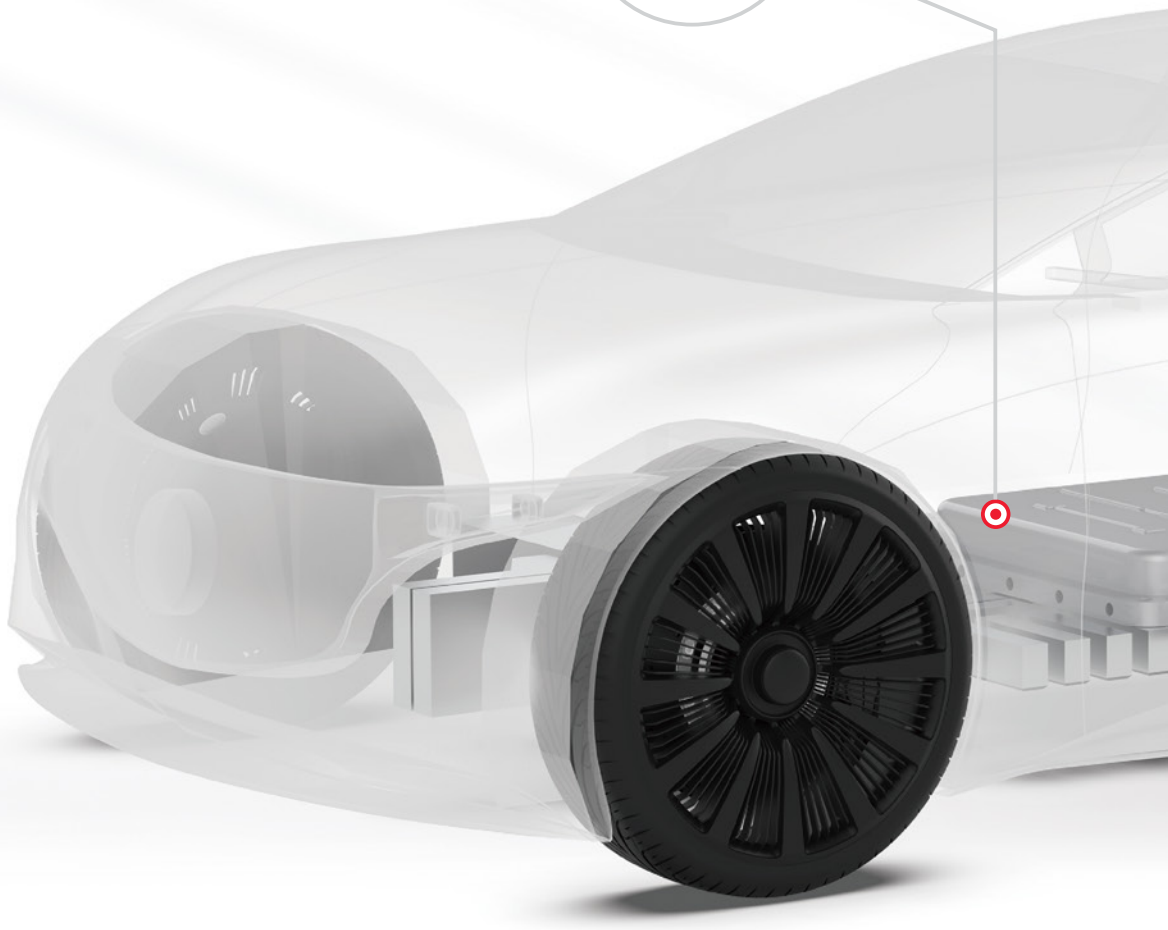

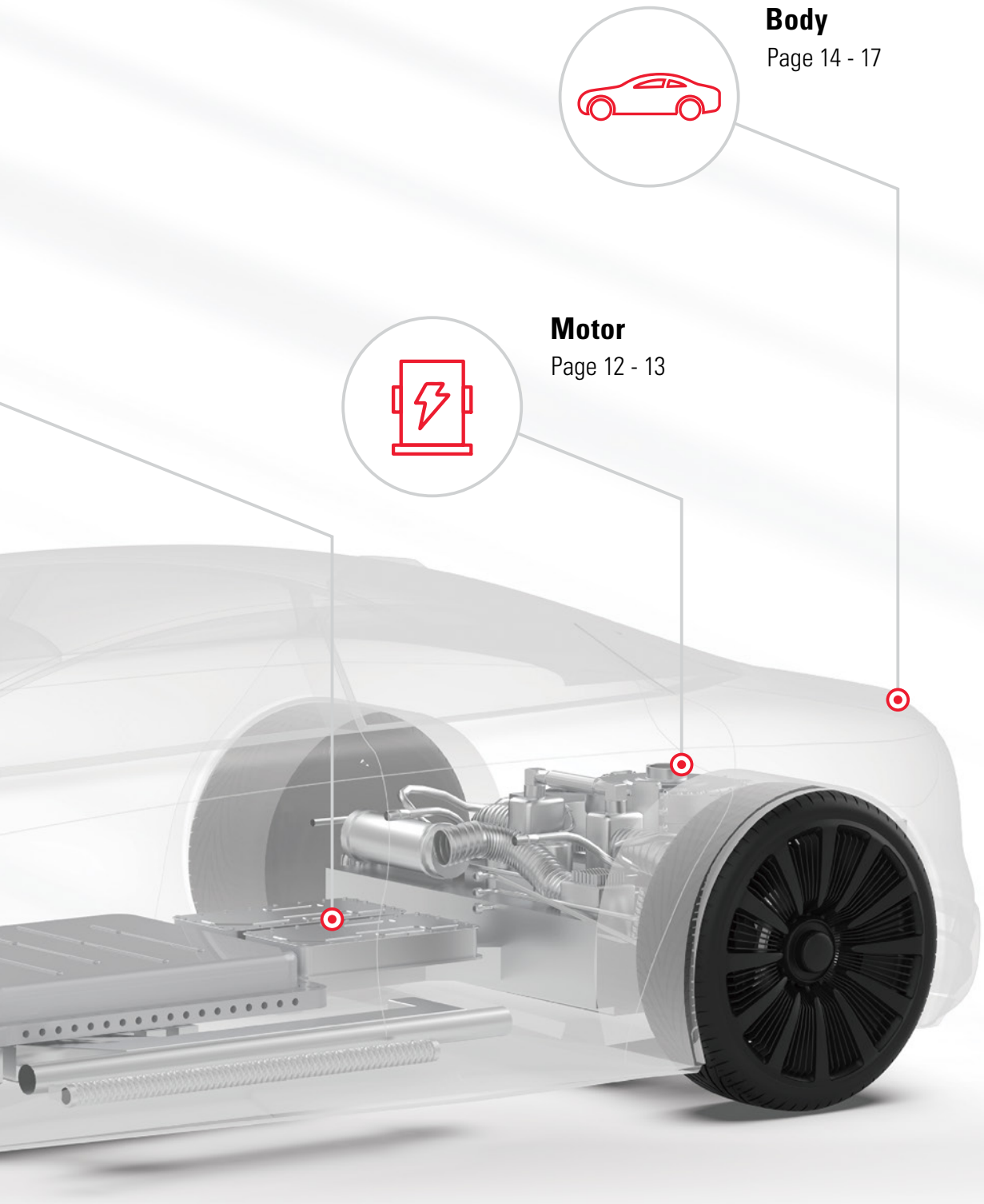

Body
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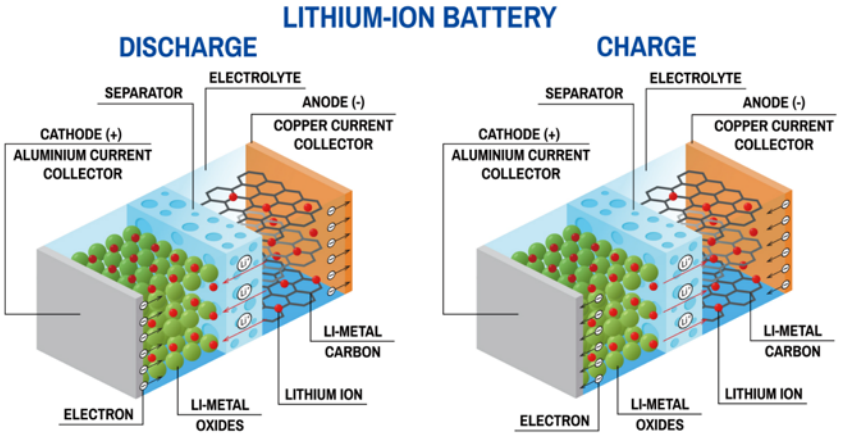
BATTERY

To further improve the safety and performance of electric vehicles, there are several challenges concerning the development and production of low-cost, reliable lithium batteries with high storage capacity.

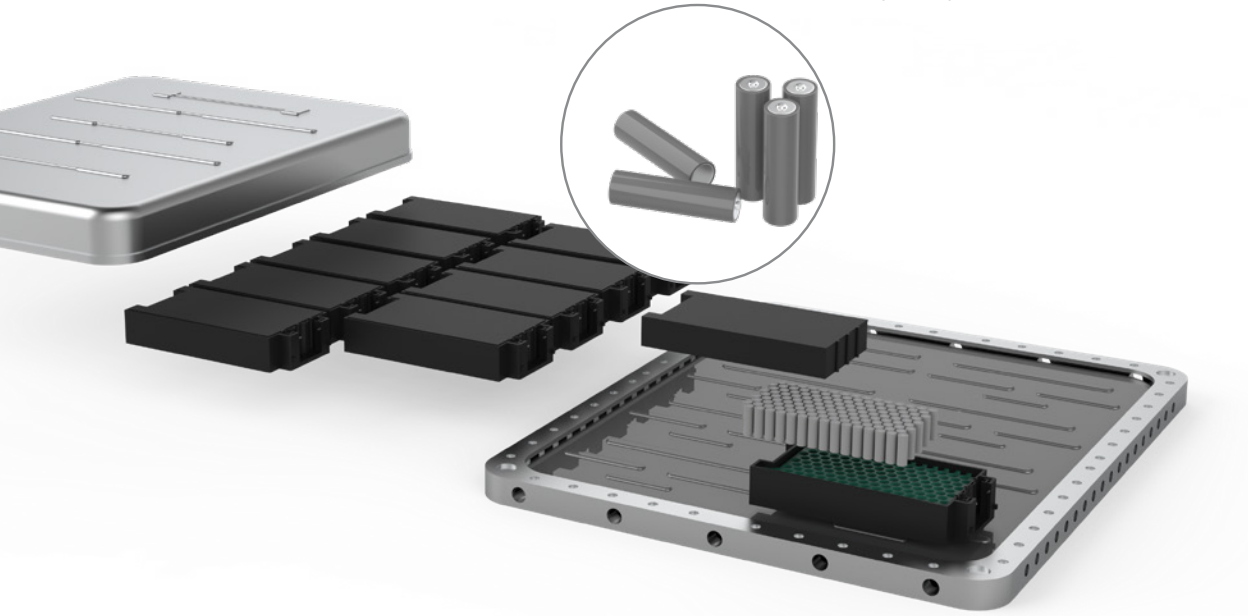
The risks of short circuits, thermal runaway, and fire caused by particle contamination, burrs, and critical defects on battery electrodes must be minimized. To overcome these challenges, strict quality control is required.



Components of lithium-ion (Li-ion) batteries

Quality control during battery production requires inspection of the cathode, positive electrode, and anode, negative electrode (refer to diagram above).

They must be checked for burrs at the edges as well as the presence of particles and other defects which can damage the separator. Optical microscopy solutions are useful for the QC inspection of electrodes, along with failure analysis and R&D to improve them and other battery components.

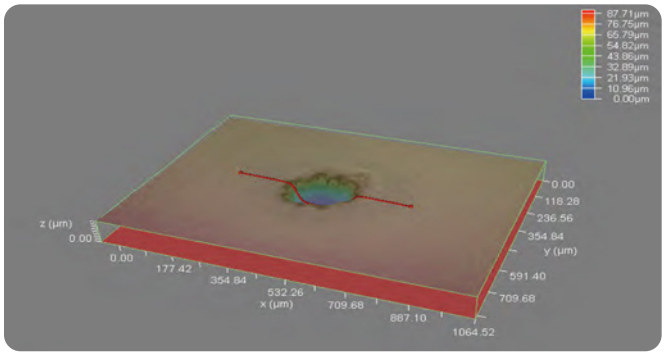


Electrode inspection

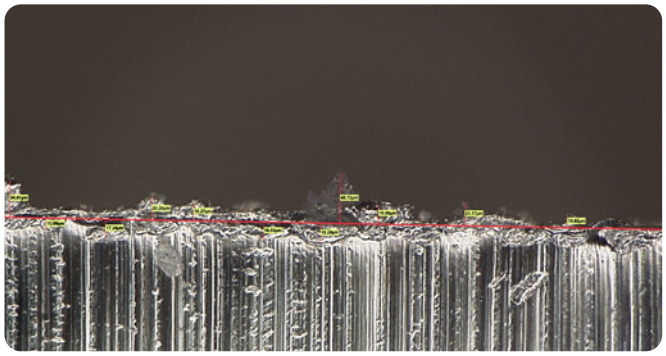
> Burr detection on electrodes
High-performance microscopes are necessary to detect and help minimize burrs at electrode edges during battery production. Burrs can pierce the separator, cause short circuits, and possibly lead to thermal runaway, explosion, and fire.

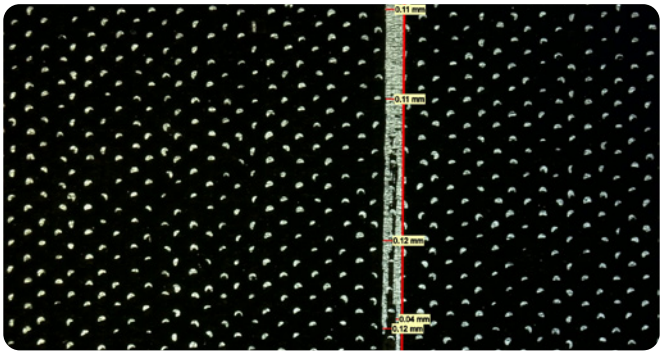
> Particle detection on electrodes
Efficient particle detection on electrodes with cleanliness analysis using visual and chemical examination during battery production is important to minimize the presence of critical particles which can severely affect battery performance and lifetime.

> Minimizing other defects on electrodes
Visual inspection of electrodes for other defects, e.g., impurities, coating blow holes, or wavy edges, at the early stages of battery production is crucial. Also, these defects can significantly reduce performance and reliability.



A 3D measurement of a pinhole in a battery eletrode.


Analysis of burrs at a battery electrode edge.



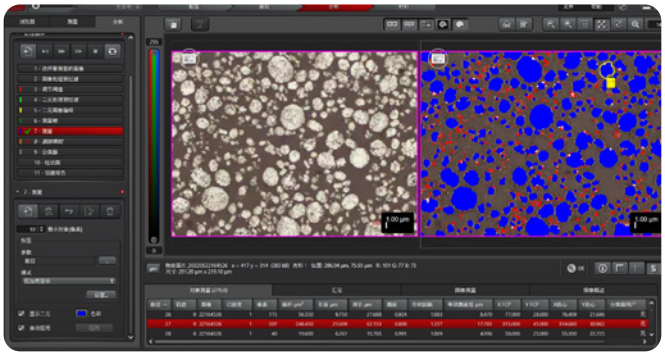
Scratches on the surface of an electrode sheet.

BATTERY

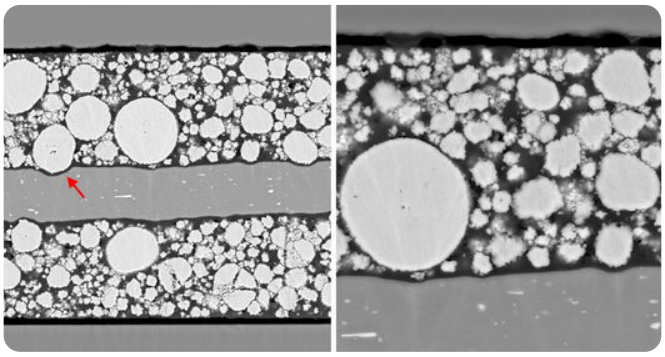
Cross section analysis of electrodes

A deep understanding of battery electrodes requires cross-section analysis during QC, failure analysis, and R&D to evaluate the internal structure. However, cross-section preparation of electrodes can be challenging. Brittle materials may chip excessively and softer materials may smear, obscuring structures.

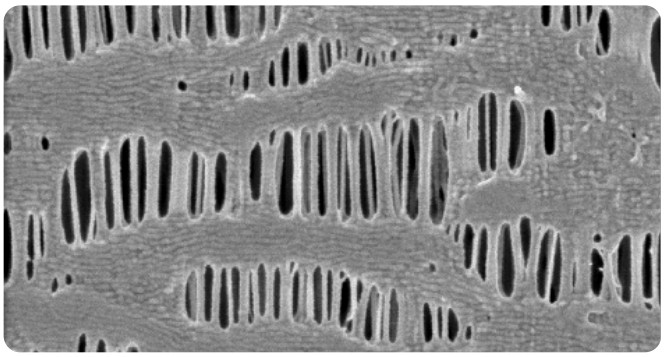
The use of mechanical and ion-beam milling systems to prepare electrode cross sections can avoid such artifacts. High-resolution microscopy provides details of an electrode's internal structure and layers.



Cross section of a battery eletrode.



Images of a battery electrode cross section.



Structural details of a lithium battery separator.

Leica solutions

To fulfill the needs of EV manufacturers concerning inspection, QC, failure analysis, and R&D of batteries, Leica Microsystems provides state-of-the-art solutions for sample preparation and microscopic observation and analysis. Leica solutions can help with the optimization of battery performance and production processes.

For battery electrode inspection, there several Leica solutions available, including stereo, digital, and metallographic compound microscopes.

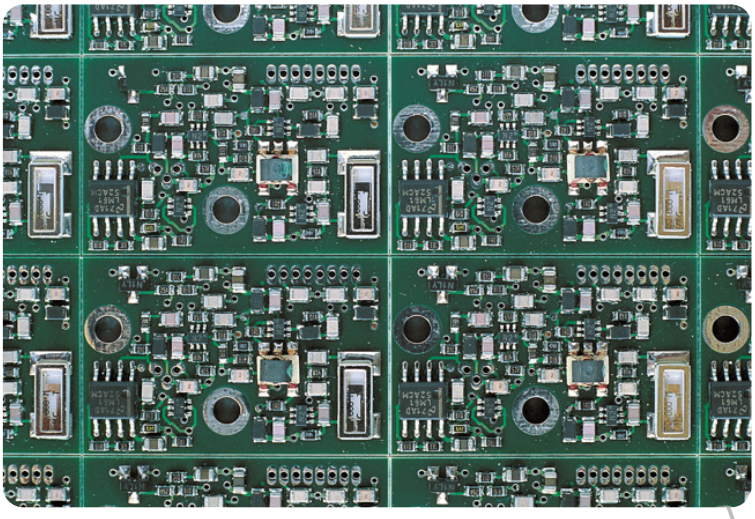
For cross section analysis of electrodes, there are Leica sample preparation systems based on mechanical or ion-beam milling along with the microscopes mentioned above. When preparing cross sections, it is also possible to maintain and handle samples in an inert atmosphere or vacuum.

DM2700 M microscope with the Flexacam c5 camera.

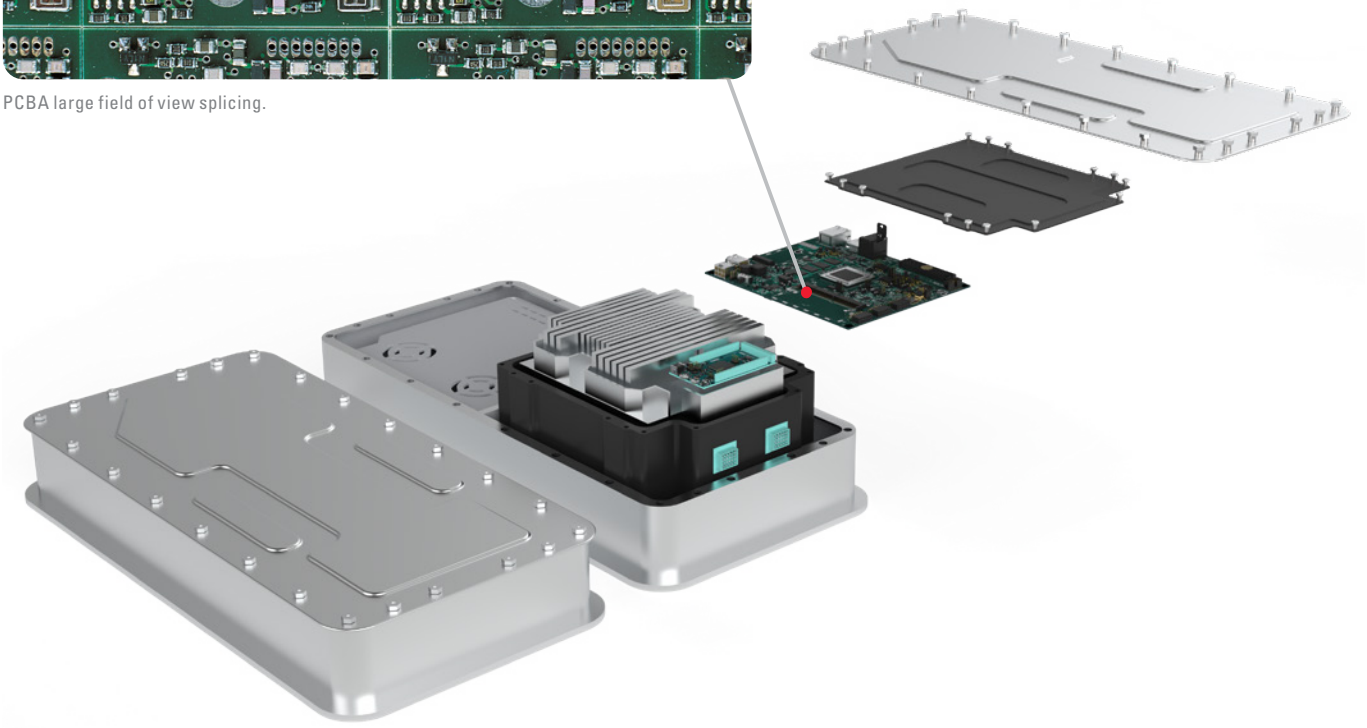
POWER ELECTRONICS CONTROLLER

The user operation of an electric vehicle occurs via the power electronics controller. Additionally, special functions and programs, like “intelligent driving capabilities”, can be implemented in the controller to enhance vehicle operation and safety.

Of course, the electronic and semiconductor components of the controller, i.e. PCBs, IC chips, and display panels, require inspection and QC during production, as well as failure analysis and R&D for constant improvement.



PCBA large field of view splicing.



PCB and component inspection

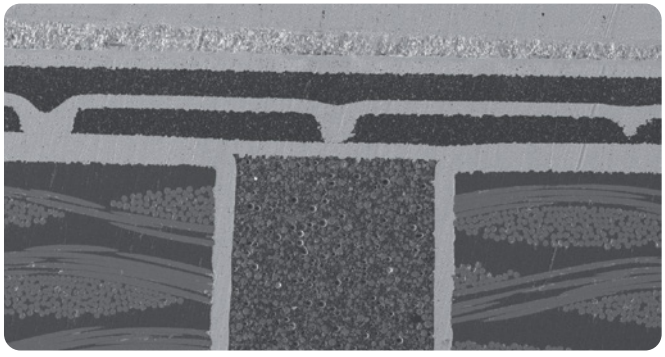
Fast and reliable PCB inspection is important for power electronics controller performance. It can be achieved with a combination of optical microscopy and chemical analysis for visualizing defects and determining their chemical composition.

Technical cleanliness of PCBs and components

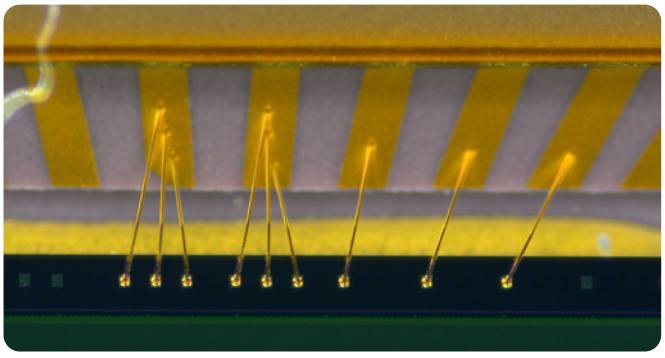
Contamination with conducting particles can cause short circuits and harm the performance of PCBs and their components. To minimize the presence of critical particulate contamination, an efficient cleanliness analysis for QC can be achieved with microscopy solutions.

Cross section analysis of PCBs

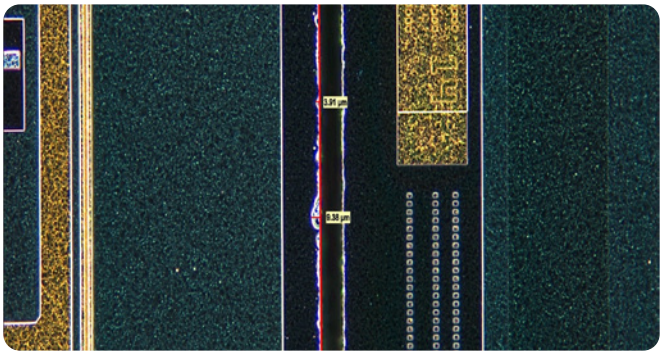
To help maintain PCB performance by minimizing internal defects, the internal structure of PCB boards and components can be investigated with cross-section analysis, whether for QC, failure analysis, or R&D. The various layers of boards and components can be examined for cracks, voids, and other defects with optical microscopy. If composition data is necessary, then the microscopy can be combined with spectroscopy.



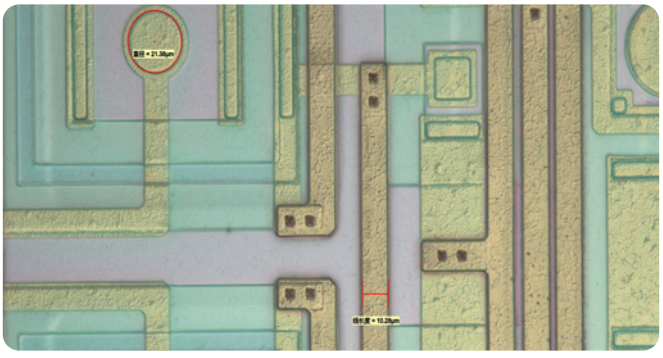
Cross section of PCB, showing an area with a soldered pin, prepared with the EM TXP system.



Wire bonding in an IC packages.



IC chip after cutting and dicing.



Dimension measurements of leads on an IC chip.

POWER ELECTRONICS CONTROLLER

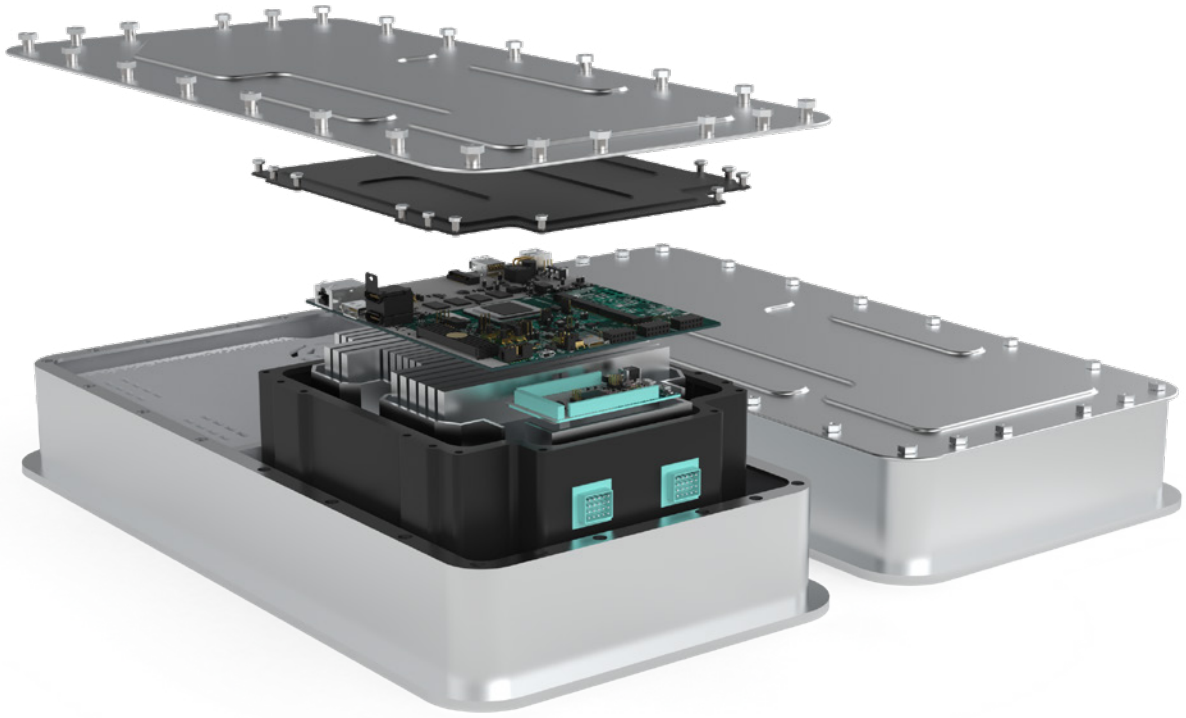
Leica solutions

Concerning QC, failure analysis, and R&D of EV power electronics controllers, Leica solutions for sample preparation and microscopic observation and analysis can help manufacturers optimize controller performance and production.

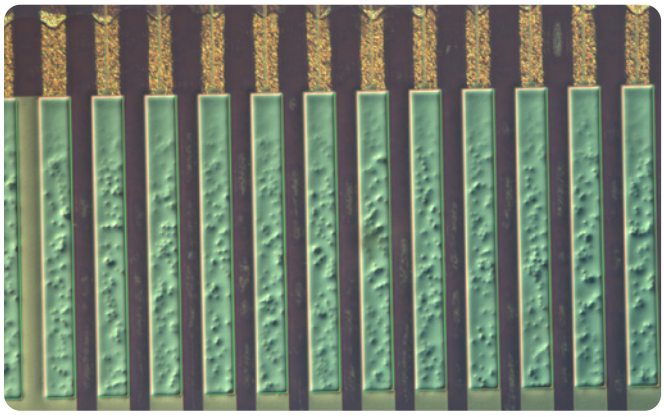
There are a range of Leica stereo, digital, and compound microscopes for PCB and wafer inspection.

Rapid and reliable technical cleanliness of PCBs and semiconductor components is addressed with Leica cleanliness analysis solutions. Fast and precise wafer and semiconductor inspection to ensure the quality and reliability of components can be performed with Leica microscope solutions for 8”/200 mm, 12”/300 mm, and 6”/150 mm wafer inspection.

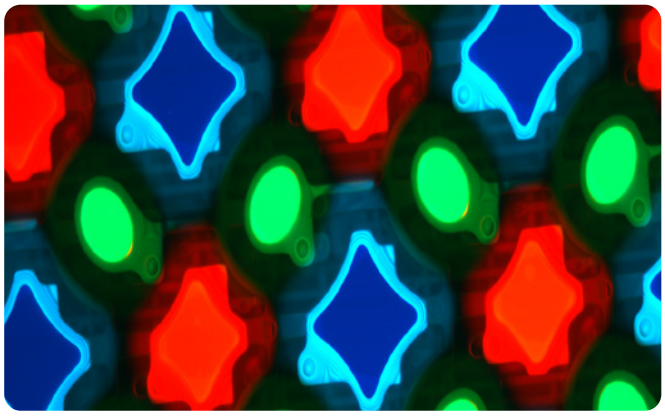
Leica sample preparation systems based on mechanical or ion-beam milling along with stereo, digital, and compound microscopes enable efficient PCB cross section analysis.



DM8000 M high throughput 8" inspection system.



Contamination on the leads of an OLED display.



RGB pixels of an OLED display.

MOTOR

The motor is the heart of electric vehicles and consists of 3 main parts: stator, rotor and casing. To deliver the ever-increasing desired vehicle performance, the motor should be efficient and reliable, so the load-bearing strength of the stator, rotor, and casing must be improved to overcome the challenges of achieving high torque, high drive efficiency, flexible torque control, etc. A more precise analysis of material properties and technical cleanliness, i.e., for the steel alloy used in the motor, copper wires in the stator, and aluminum alloy in the casing, can contribute to this goal. For material characterization during QC and R&D, metallographic microscopes play a key role.

Material and metallographic analysis

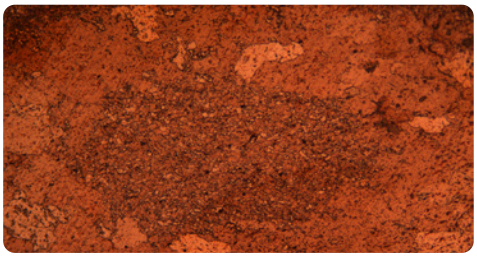
To produce high-performance motors, the properties of metals used to produce motor components must be analyzed in terms of their microstructure during QC, failure analysis, and R&D. Visual and chemical material analysis can be done with metallographic microscopes.

Parts and component inspection

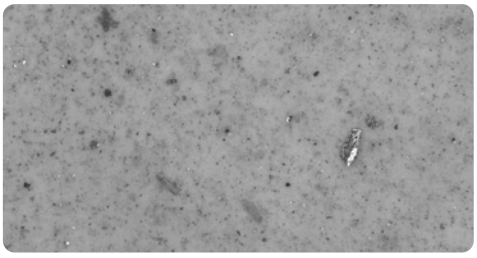
To produce reliable motors capable of high torque, high drive efficiency, and flexible torque control, strict standards for the QC, failure analysis, and development of motor parts is required. To meet challenges concerning the demand for ever-increasing motor performance, inspection of materials and parts using high-resolution metallographic microscopes is crucial.

Technical cleanliness of parts and components

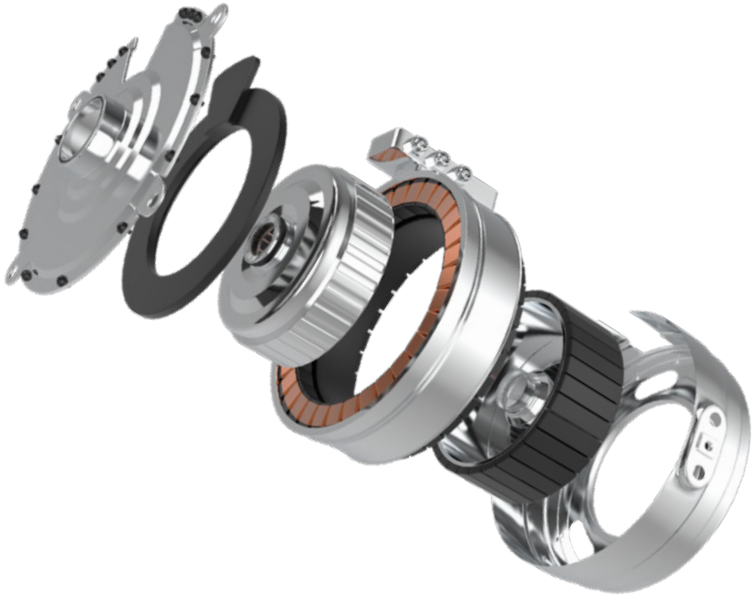
When large "killer" particles are present in the motor, they can strongly impact its performance and lifetime. To find and eliminate sources of contamination rapidly, cleanliness analysis using optical microscopy and spectroscopy makes a difference.



Observation of the microstructure of a stator copper wire.



Observation of particles extracted from components during quality control as parf of cleanliness analysis.



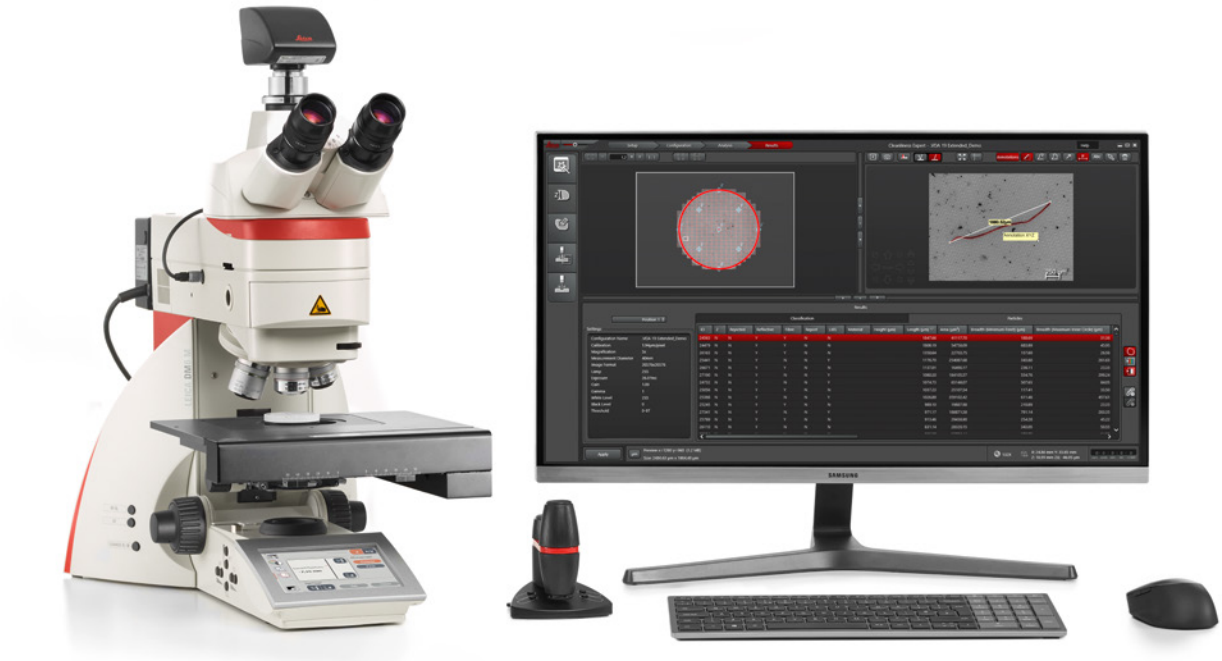
Leica solutions

Whether inspection, QC, failure analysis, or R&D of EV motors, Leica microscope solutions can help with the optimization of motor performance and production.

Material and metallographic analysis is efficiently performed with Leica metallographic microscopes.

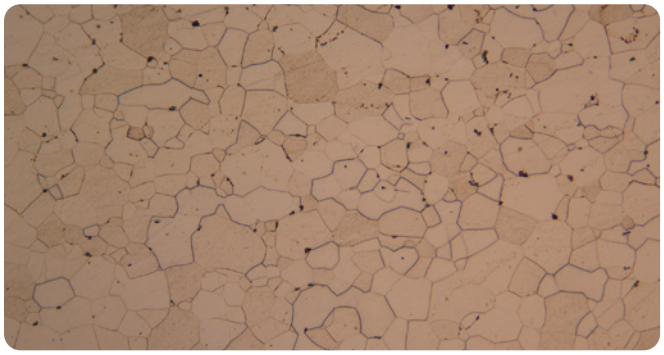
For parts and components inspection, there are a range of Leica stereo and digital microscopes.

Technical cleanliness is done rapidly and reliably using Leica cleanliness analysis solutions with both visual and chemical examination of particles.



DM6 M microscope, K3 camera, and Cleanliness Expert analysis software.

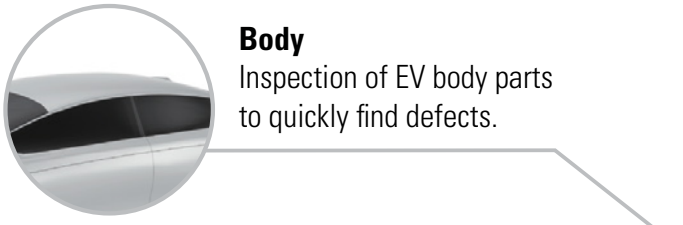
Structure of steel which has undergone decarburization. The sample is from an electric motor shaft.



Microstructure of silicon steel showing its grains.

BODY

The body (frame, panels, bumpers, painting and coatings, wheels, tires, etc.) of an electric vehicle also plays an important role in determining its performance and safety. The body parts and components must be light, strong, and stable. Even small flaws in the materials used for body parts may affect the vehicle's performance. To improve body parts, inspecting for defects in materials the parts are made from, the surface texture of tires, and impurities in paints and coatings is vital. Inspection, failure analysis, and R&D of body parts can be done with optical microscopy solutions.



Body
Inspection of EV body parts to quickly find defects.

Bumper
Inspect for cracks in the EV bumper and quantitatively analyze and measure any which are observed.

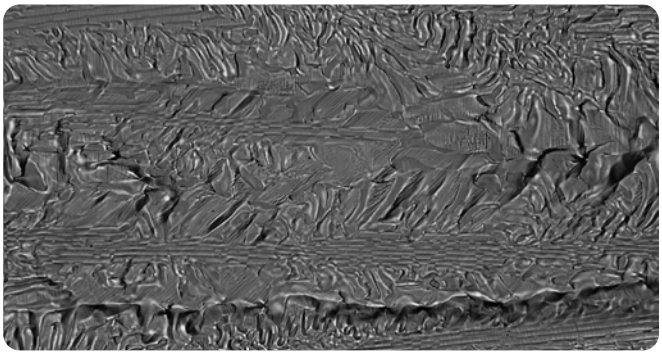


Image of a fracture in metal: A metallographic microscope was used for analysis.

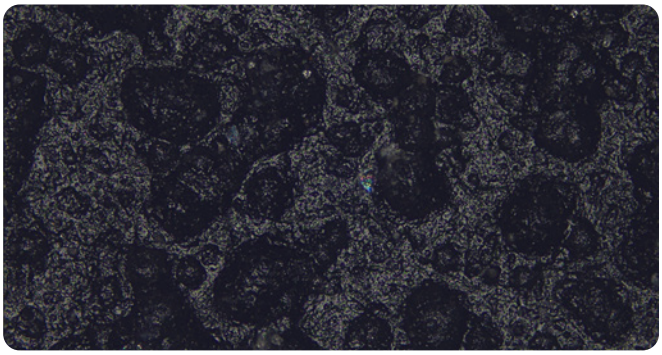


Image of a rubber-tire surface: Brightfield imaging can be useful for QC.

Paint & Coatings
Inspection and 2D/3D analysis of paint and coatings on EV body parts to find impurities and contamination.

Wheel Hub & Tire
Cracks in wheel fastening bolts can be observed by a microscope with a large depth of field. Further analysis can be done to determine the cause of the cracks.

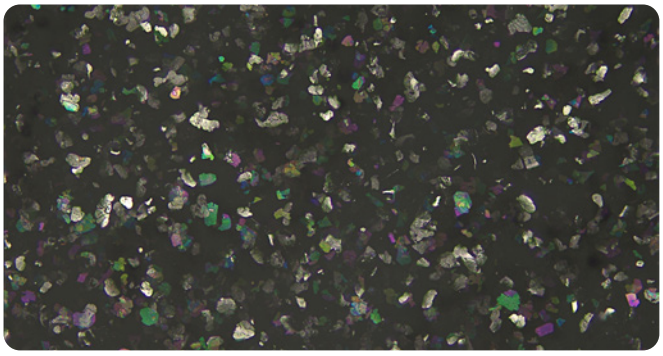


Image of a paint sample: Brightfield imaging can be used for inspection of painted and coated surfaces.

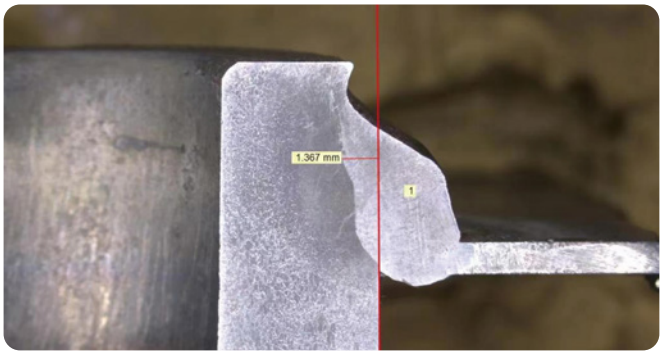


Image of a welded part showing a depth measurement.

BODY

Parts and component inspection

Strict standards are required for production of electric vehicle parts and components to meet expected vehicle performance and reliability. These standards can be fulfilled efficiently using high-resolution inspection microscopes for QC, failure analysis, and R&D.

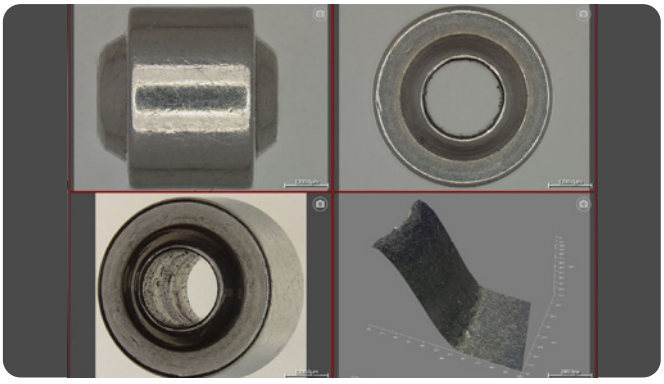
Material and metallographic analysis

- Material bulk and surface
  As a part of QC, failure analysis, and R&D, the microstructure and composition of materials and metal alloys used to construct body parts can be analyzed with metallographic microscopes. Examination of welded body parts to quantify the welding groove and top might lead to more accurate welding. Microscale surface morphology can be determined as well. The surface texture of a tire can help predict its lifetime and analysis of cracks generated during use may determine their cause and eventually lead to improved performance.

- Paint layers and coatings
  Paint layers and coatings on electric vehicle body parts should be smooth and homogeneous for performance and aesthetic reasons. Visual inspection and chemical analysis of surface coatings with material microscopes is crucial to detect impurities and defects.

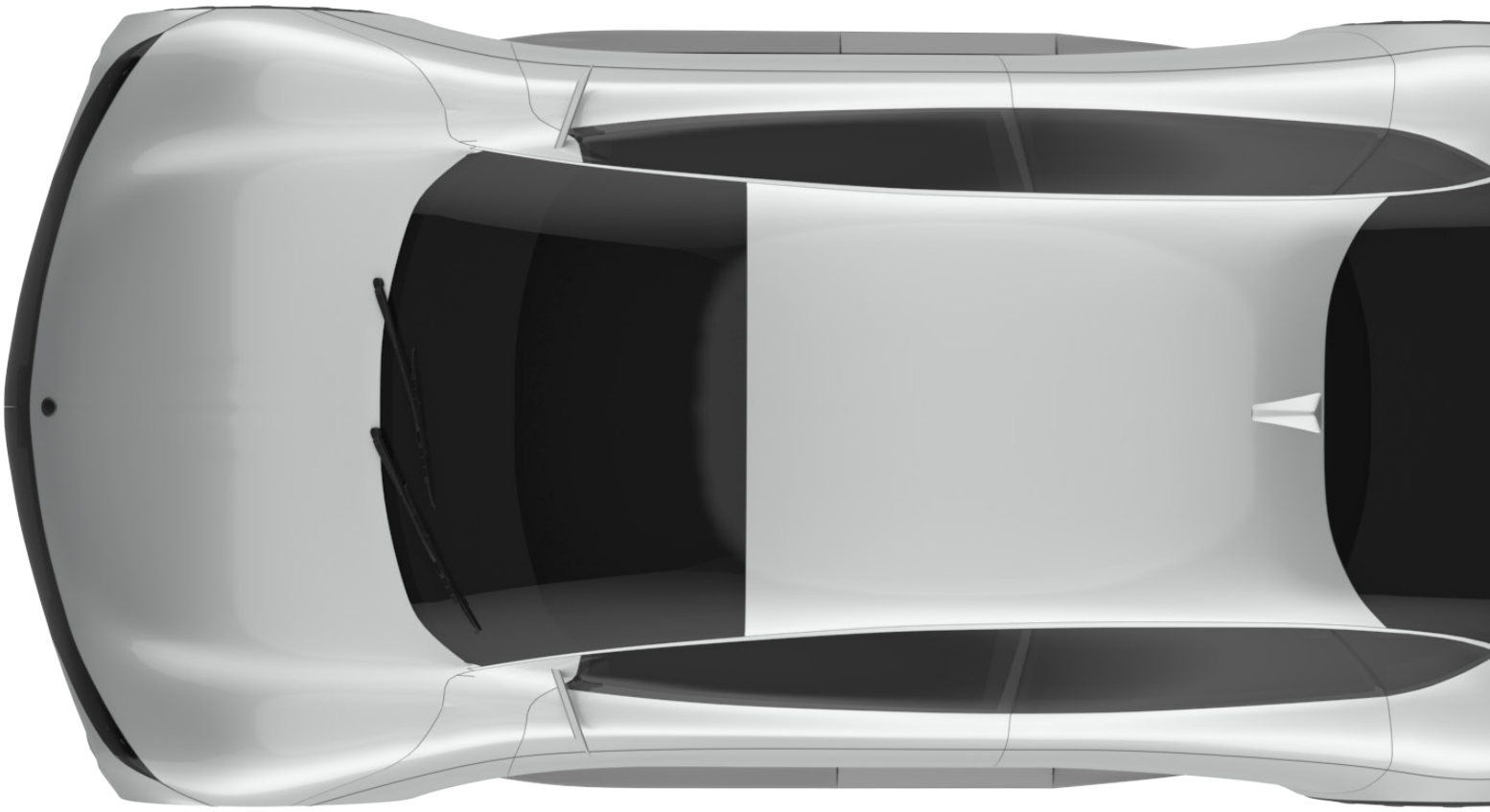
Technical cleanliness of parts and components

Particulate contamination on moving parts of an electric vehicle's body like the axes and hubs of wheels can strongly impact their performance. As for motors, finding and eliminating particle contamination sources for body parts with cleanliness analysis using optical microscopy and spectroscopy is essential.



Inspection of a metal spacer ring.

Image of a laser welded part which could be used on an EV body.



Leica solutions

Concerning the needs of EV manufacturers for the inspection, QC, failure analysis, or R&D of the EV body, Leica microscope solutions help with the optimization of performance and production of body parts and components.

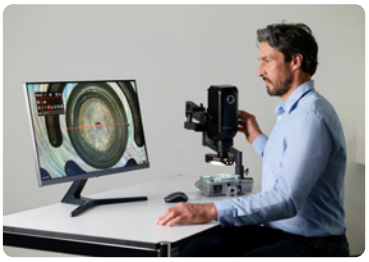
There are a range of Leica stereo and digital microscopes for the inspection of body parts and components.

Efficient material and metallographic analysis is performed with Leica metallographic microscopes.

Leica cleanliness analysis solutions with both visual and chemical examination of particles enable rapid and reliable technical cleanliness.

DVM6 digital microscope.

ELECTRIC VEHICLE PRODUCTION MICROSCOPE SOLUTIONS



Emspira 3
Digital microscope

Digital microscopes

Digital microscopes, i.e. Emspira 3 and DVM6, do not use eyepieces, so images are always observed directly on a monitor. At the same time, demand for efficient, cost-effective standards for quality and increasing demand for efficient, cost-effective R&D, microscopes are indispensable for production and development. Digital microscopes have gained popularity due to their ease of operation, comprehensive functions, and flexibility.

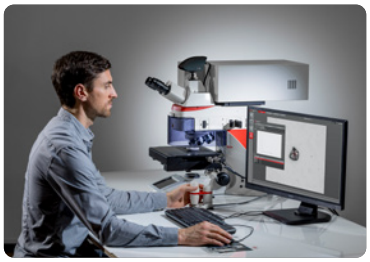
Applications: Burr detection, electrode inspeciton, PCB inspection, and parts and component inspection.

Ivesta 3
Greenough stereo microscope

Stereo microscopes

Stereo microscopes, i.e., Ivesta 3 and M series, allow you to observe, analyze, and record 2D and 3D sample images. Combined with clear LED illumination, high-performance digital cameras, and easy-to-use Enersight software, these imaging systems provide powerful solutions for precise analysis and documentation.

Applications: Burr detection, electrode inspeciton, PCB inspection, and parts and component inspection.



DM6 M LIBS
Material analysis microscope

Material analysis microscope

The DM6 M LIBS material analysis solution is a two-in-one solution that provides fast and accurate visual inspection and chemical analysis, eliminating the need for sample preparation and transfer between instruments. The LIBS 2-in-1 solution makes it easier to identify the source of particle contamination.

Applications: Cross-section analysis, cleanlinesss analysis, and metallographic and material analysis of components.

Semiconductor and wafer inspection microscopes

Electric vehicles (EVs) have become more and more popular with consumers. At the same time, the requirements for inspection, quality control and assurance (QC/QA), failure analysis, and research and development (R&D) are rapidly increasing. The DM8000 M or DM12000 M microscopes for inspection of semiconductor components and 8” or 12” wafers allow users to go quickly from an overview to resolving fine details in regions of interest. Multiple illumination methods, including ultraviolet (UV) light, enhance contrast and resolution.

Applications: Wafer and semiconductor component inspection.

DM8000 M
Semiconductor and wafer inspection microscope

Sample preparation solutions

Efficient preparation of cross sections, whether battery electrodes, PCBs, PCB components, or motor or body parts, can be performed with Leica target preparation or ion-beam milling solutions. Afterwards, the cross sections can be analyzed with optical or electron microscopy. Sawing, mechanical milling, grinding, and polishing can be done with the EM TXP system. Ion-beam milling is performed with the EM TIC 3X.

Applications: Preparation of cross sections for PCBs, semiconductor components, and materials used in parts and components.

EM TIC 3X
Ion Beam Milling System

CONNECT
WITH US!

Leica Microsystems GmbH | Ernst-Leitz-Strasse 17–37 | D-35578 Wetzlar (Germany)
Tel. +49 (0) 6441 29-40 00 | F +49 (0) 6441 29-41 55

www.leica-microsystems.com