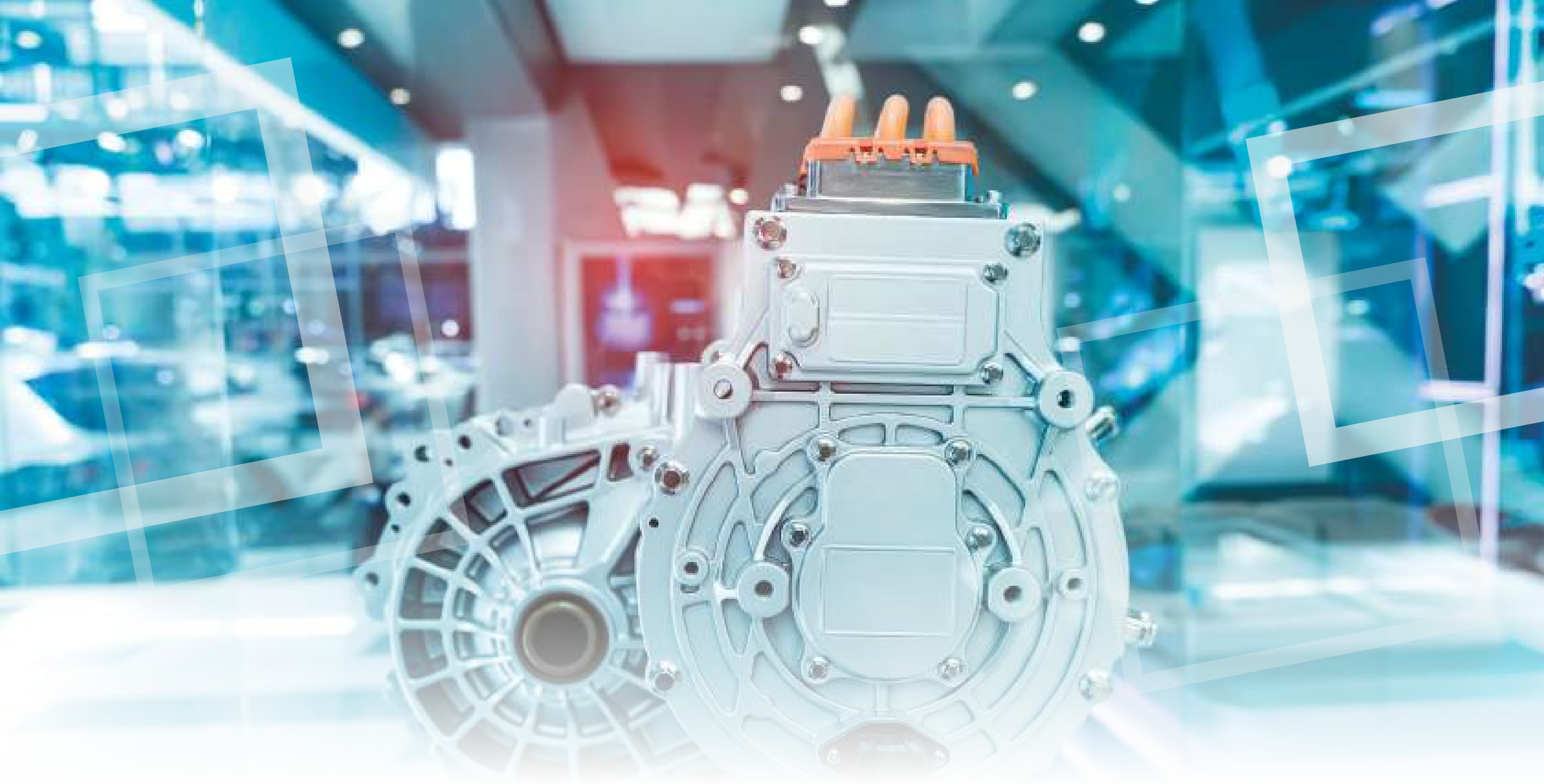


EV batteries characterization

Driving innovation in non-contact 3D surface metrology for EV batteries

SENSOFAR

INTRODUCTION

Electric vehicles (EVs) are becoming more popular as a sustainable and efficient alternative to conventional vehicles. However, EVs rely on high-performance batteries that need to meet strict quality and safety standards.

Exploring battery types for EVs

Several types of batteries are used in EVs, each with its advantages and disadvantages. Lithium-ion batteries are the most common type of battery used in EVs, but they have some challenges, such as flammability, weight, and energy density. Researchers and manufacturers are developing new battery concepts to overcome these challenges, such as solid-state batteries that use solid electrolytes instead of liquid ones. These batteries promise to be safer, lighter, and more energy-dense than current lithium-ion batteries. These are the four types of batteries considered for EVs:

LITHIUM-ION BATTERIES

They offer high energy density and are relatively lightweight. Lithium-ion batteries also have a long lifespan and can be recharged quickly. However, their manufacturing expenses are considerable and they may encounter heat-related problems.

Cost ●●●○ | Safety ●●○○ | En. density ●●●○ | Durability ●●●○

NICKEL-METAL HYDRIDE BATTERIES

They have a lower energy density than lithium-ion batteries and are larger and heavier for the same amount of energy storage. However, they are less expensive to manufacture and less prone to overheating than lithium-ion batteries.

Cost ●●○○ | Safety ●●●○ | En. density ●●○○ | Durability ●●●○

LEAD-ACID BATTERIES

Like nickel-metal hydride batteries, they are heavy and have a low energy density. They are also less durable than other types of batteries and require regular maintenance. However, they are less expensive to manufacture and are still used in some low-speed electric vehicles.

Cost ●●○○ | Safety ●○○○ | En. density ●○○○ | Durability ●○○○

SOLID-STATE BATTERIES

This emerging technology is still under development but shows promise for usage in EVs. They use a solid electrolyte instead of a liquid electrolyte, which can improve safety and energy density. Solid-state batteries also have the potential to be lighter, smaller, and more durable than lithium-ion batteries. However, they are still more expensive to manufacture than other types of batteries and are not yet widely available.

Cost ●●●● | Safety ●●●○ | En. density ●●●● | Durability ●●○○

Quality control in batteries production

Producing batteries for EVs is not a simple task. It requires precise control of every manufacturing process step: electrode preparation, battery assembly, and finishing. Any defect or deviation from the specifications can compromise the performance and safety of the battery. Therefore, quality control is essential for ensuring reliable and consistent battery products.

ELECTRODE PREPARATION

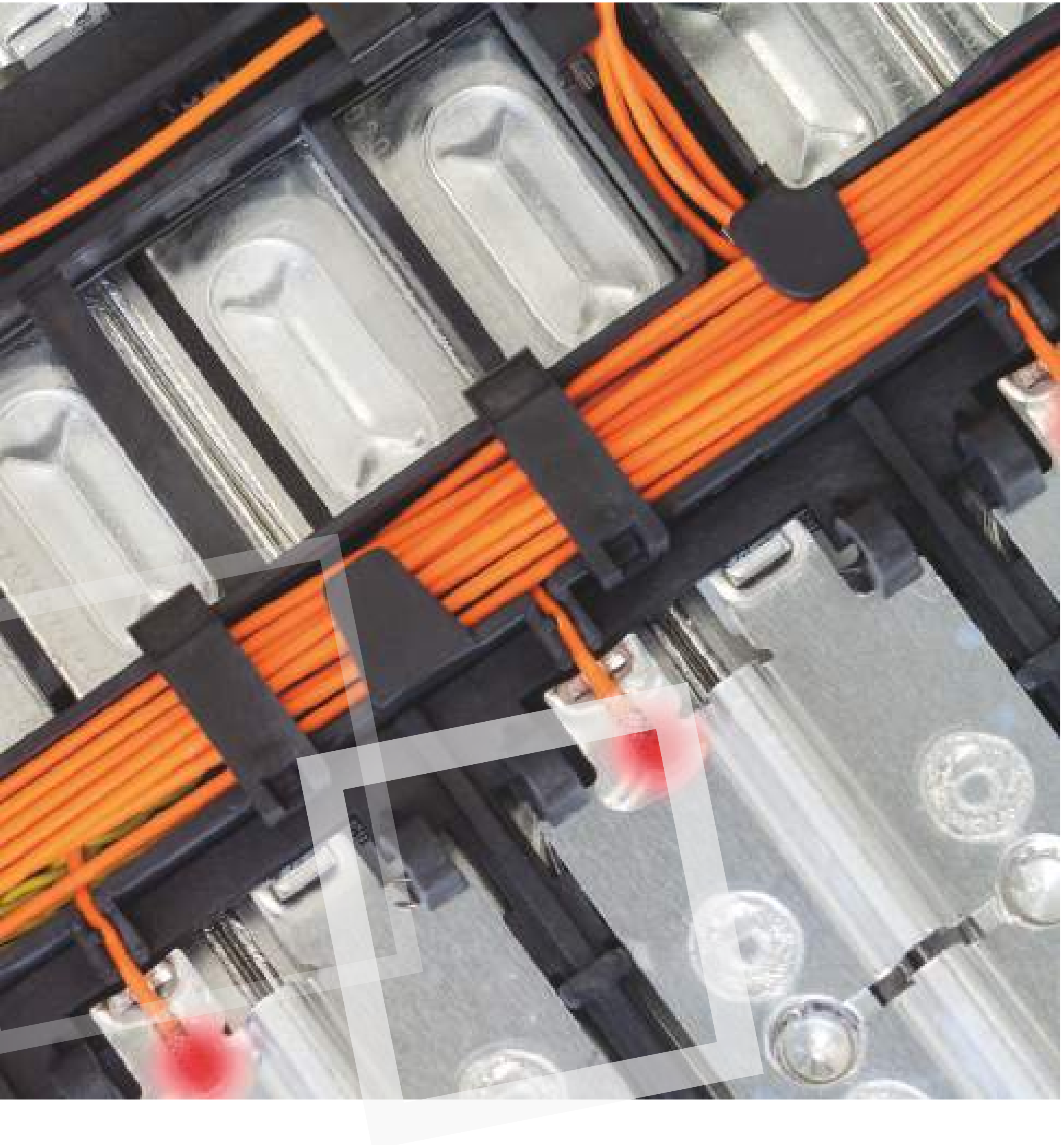
The roughness of electrode materials can affect the coating process and must be optimized to ensure good adhesion.

BATTERY ASSEMBLY

After coating and before stacking them into cells, the roughness of electrode sheets can be measured to ensure uniformity across cells and avoid defects such as cracks or delamination.

DURING FINISHING

After sealing finished cells or modules into cases or packs, the roughness can be measured to detect any damage or degradation caused by handling or aging.



The importance of areal measurements

Non-contact 3D optical metrology techniques are ideal for measuring these surface properties accurately and efficiently. These techniques use light to **capture high-resolution images of surfaces without touching or damaging them**. They provide fast, reliable surface texture, flatness, and critical dimensions data.

When discussing roughness measurements, it is important to mention the distinction between profile and area analysis.

Measuring roughness in an area offers a more complete understanding of surface texture than measuring roughness in a profile.

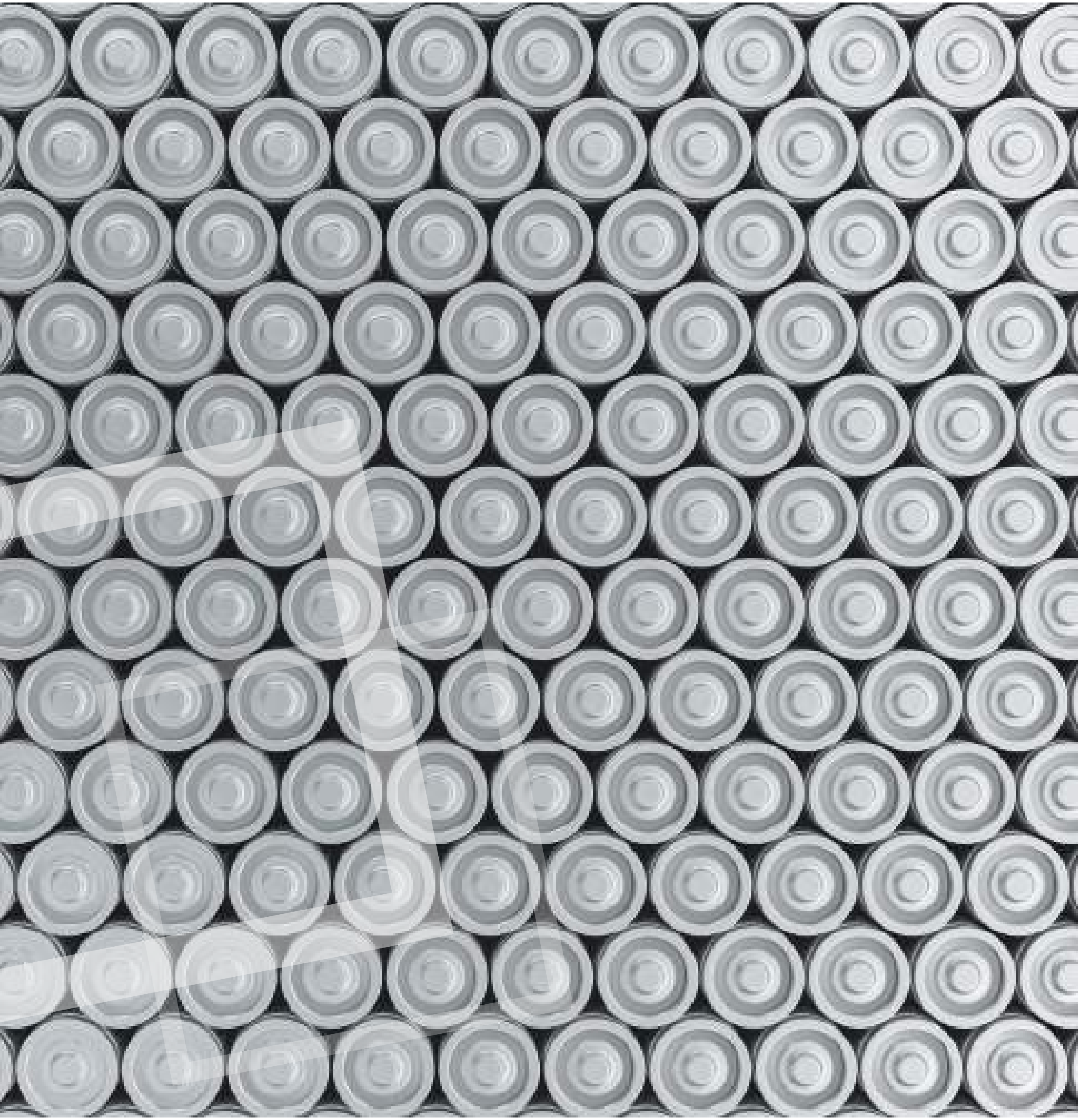
While a profile only measures height variations along a single line, **roughness in an area** considers height variations across the entire surface. This **offers a more comprehensive picture of the surface texture**, revealing important information about its topography, features, and distribution. Calculating roughness in an area enables manufacturers to optimize manufacturing processes, improve product performance, ensure quality control, and achieve greater customer satisfaction.

Role of optical metrology in battery repair

In addition to the importance of quality control during battery production, the repair of batteries is also becoming an increasingly important topic in the EV industry. As EVs become more common, the number of batteries needing repair or replacement is also increasing. **Battery repair can be a cost-effective and sustainable alternative to replacing entire batteries**. Still, it requires accurate and precise measurements to ensure the repaired batteries meet safety and performance standards.

Repaired batteries may have different metrology requirements than new batteries. For example, the surface properties of repaired batteries components may be altered due to wear or damage, which can affect their performance. As a result, accurate measurements of surface properties such as roughness and flatness are essential to ensure that repaired batteries meet the specified standards.

Non-contact 3D optical metrology techniques are suitable for measuring the surface properties of repaired batteries. By using these techniques, manufacturers can ensure that repaired batteries meet the same high standards as new batteries and that the fixed batteries are safe, reliable, and efficient.



HOW CAN WE HELP?

One of the key aspects of battery quality control is measuring and characterizing the surface properties of battery components. Surface properties such as roughness, flatness, thickness, and morphology can affect battery performance and factors such as adhesion, conductivity, and capacity retention.

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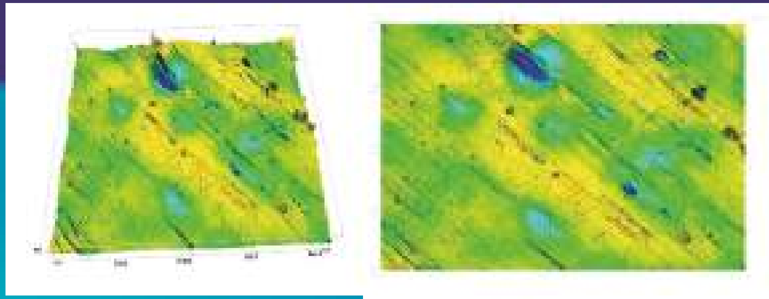
HOW CAN WE HELP?

Roughness through battery layers

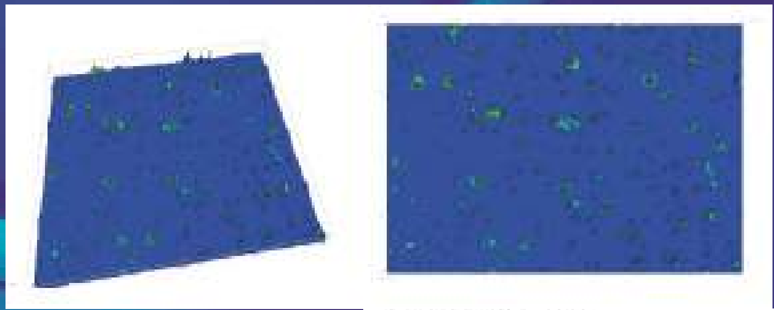
Surface roughness is one of the key parameters that influences the quality of batteries. The roughness of electrode layers affects their electrochemical activity, adhesion with other materials (such as binders or separators), contact resistance, and heat dissipation. Roughness measures how smooth or irregular a surface is at a microscopic level. Therefore, controlling roughness during battery production is essential for ensuring optimal battery function. 3D optical profilometers like the ones produced by Sensofar can measure roughness with high resolution and accuracy using non-contact optical metrology techniques such as Confocal, Interferometry, or Ai Focus Variation.

Checking the roughness of the constituent layers of the battery becomes essential. Some layers are covered with specific coatings that improve their performance: a smoother surface can promote better contact and ion transfer between the layers, improving battery performance and longevity.



ISO 25178 / Height

Sa	1.0047 µm	Ssk	0.9580
Sku	6.5278	Sv	9.1139 µm
Sp	7.5873 µm	Sz	16.701 µm
Sq	1.3329 µm		



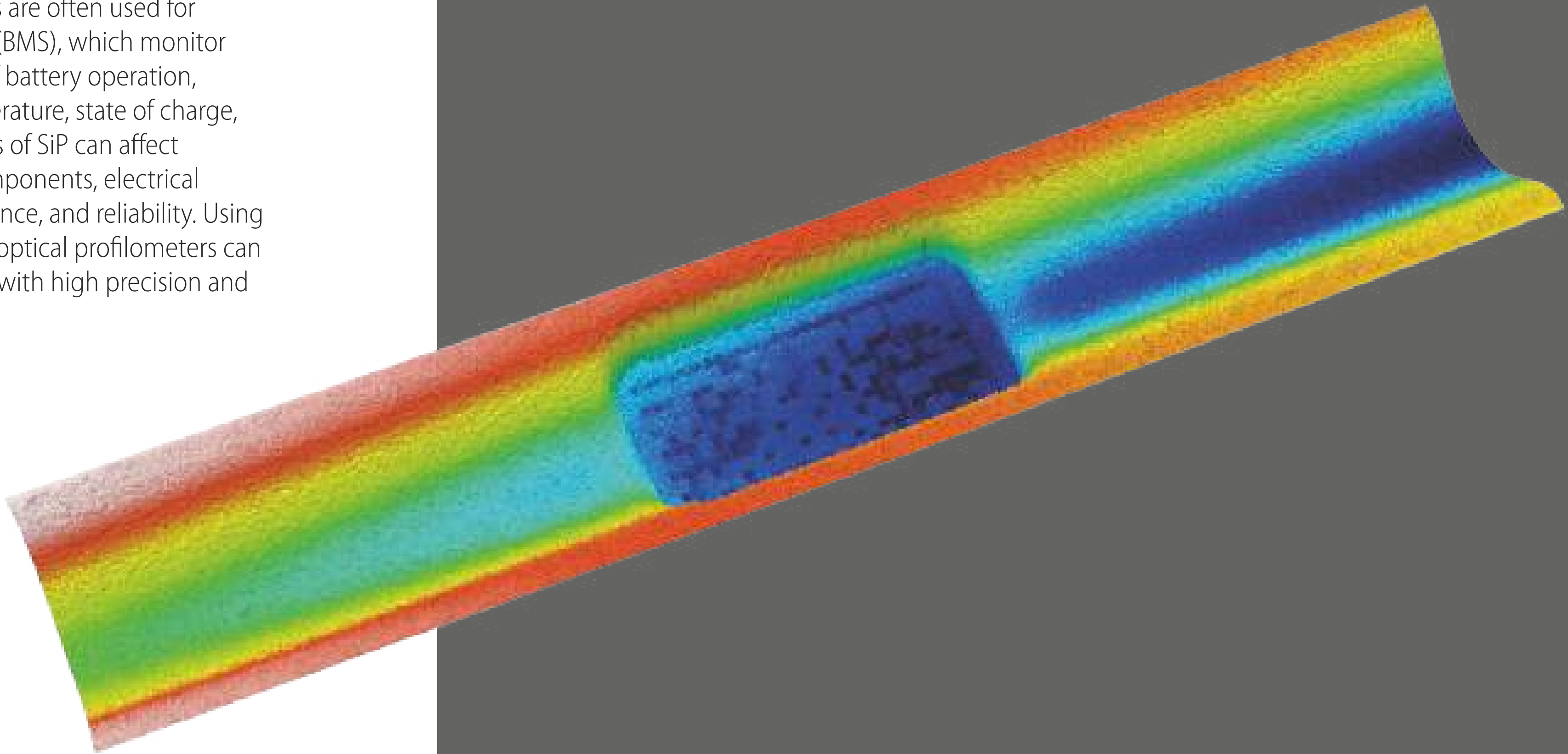
ISO 25178 / Height

Sa	0.4636 µm	Ssk	3.2075
Sku	16.9479	Sv	1.2560 µm
Sp	8.5085 µm	Sz	9.7645 µm
Sq	0.7305 µm		

HOW CAN WE HELP?

SiP flatness

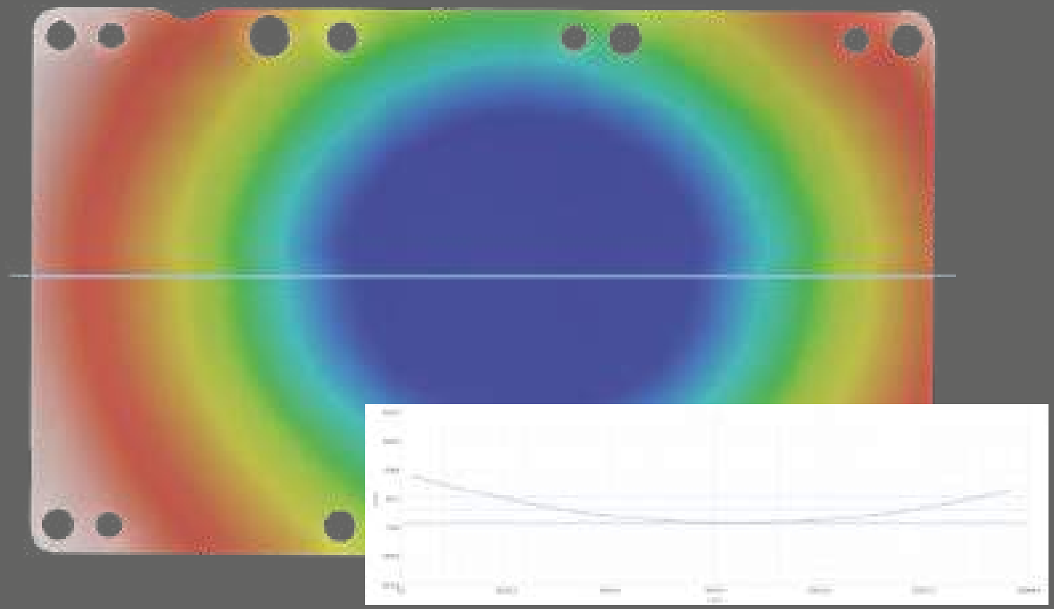
SiP (System-in-Package) refers to packaging technology where multiple components (such as sensors, controllers, or communication modules) are integrated into a single package that occupies less space and reduces wiring complexity. SiPs are often used for Battery Management Systems (BMS), which monitor and regulate various aspects of battery operation, such as voltage, current, temperature, state of charge, and state of health. The flatness of SiP can affect their alignment with other components, electrical connectivity, thermal performance, and reliability. Using Interferometry techniques, 3D optical profilometers can measure SiPs package flatness with high precision and repeatability.

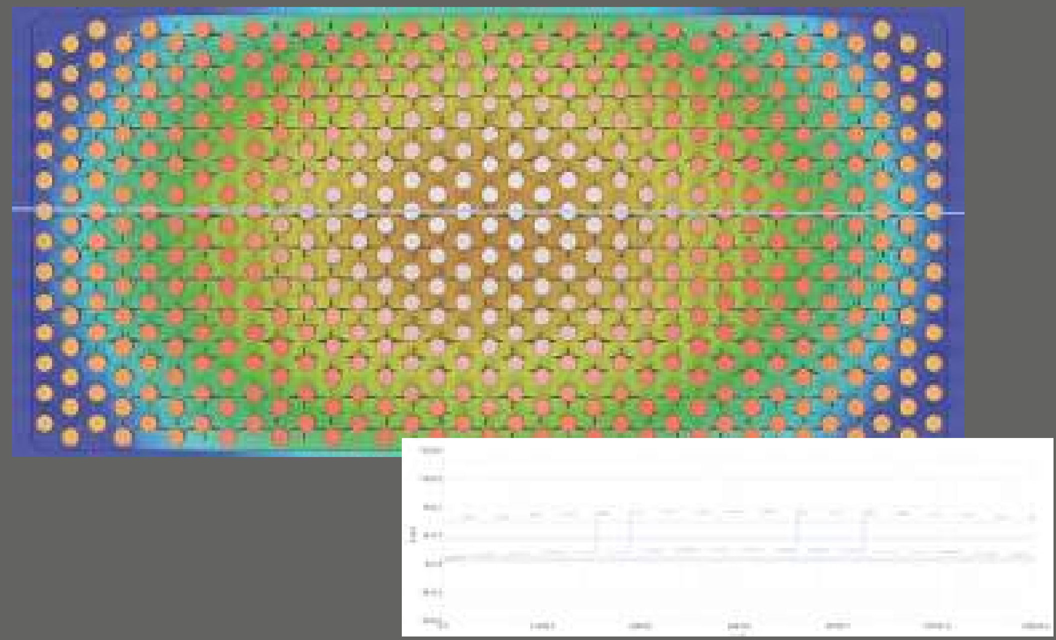


HOW CAN WE HELP?

Heat sink flatness

The flatness of heat sink is a critical factor in the performance of a battery. As a passive cooling device that dissipates the heat generated by the battery modules, the warpage of the heat sink can significantly impact battery efficiency. To ensure proper assembly between the battery module and the heat sink, we utilize Fringe Projection technology, enabling fast and accurate assessment of heat sink flatness.





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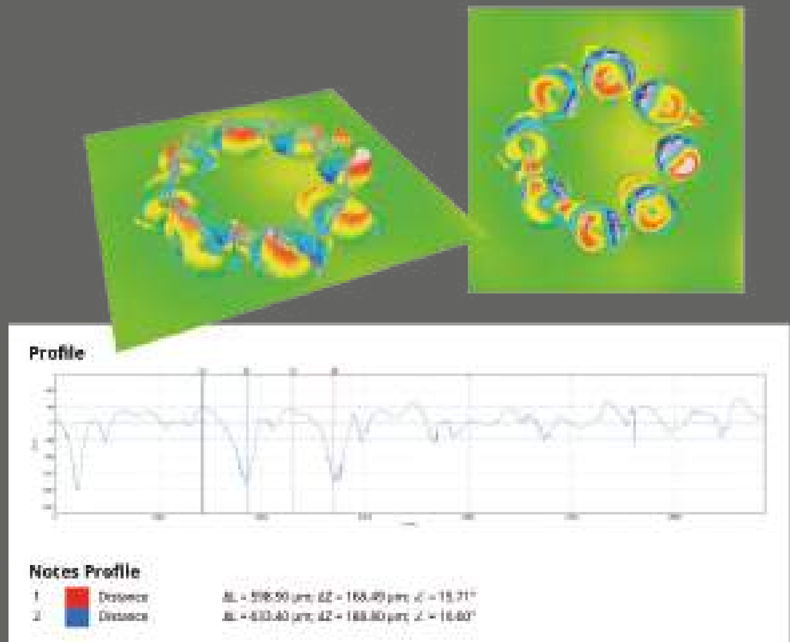
HOW CAN WE HELP?

Battery plate maximum height

In the context of electric vehicle powertrain systems, the characterization process is focused on obtaining the highest point within the traction battery packs. This measurement helps to verify that the battery plates are positioned correctly, minimizing the risk of potential issues such as improper contact, misalignment, or possible damage during operation.

Using advanced metrology techniques, such as 3D optical profilometry, the measurement of battery plates can be conducted with high accuracy and repeatability. This ensures consistent and reliable results for quality control purposes and allows for precise adjustment and optimization during the manufacturing process.



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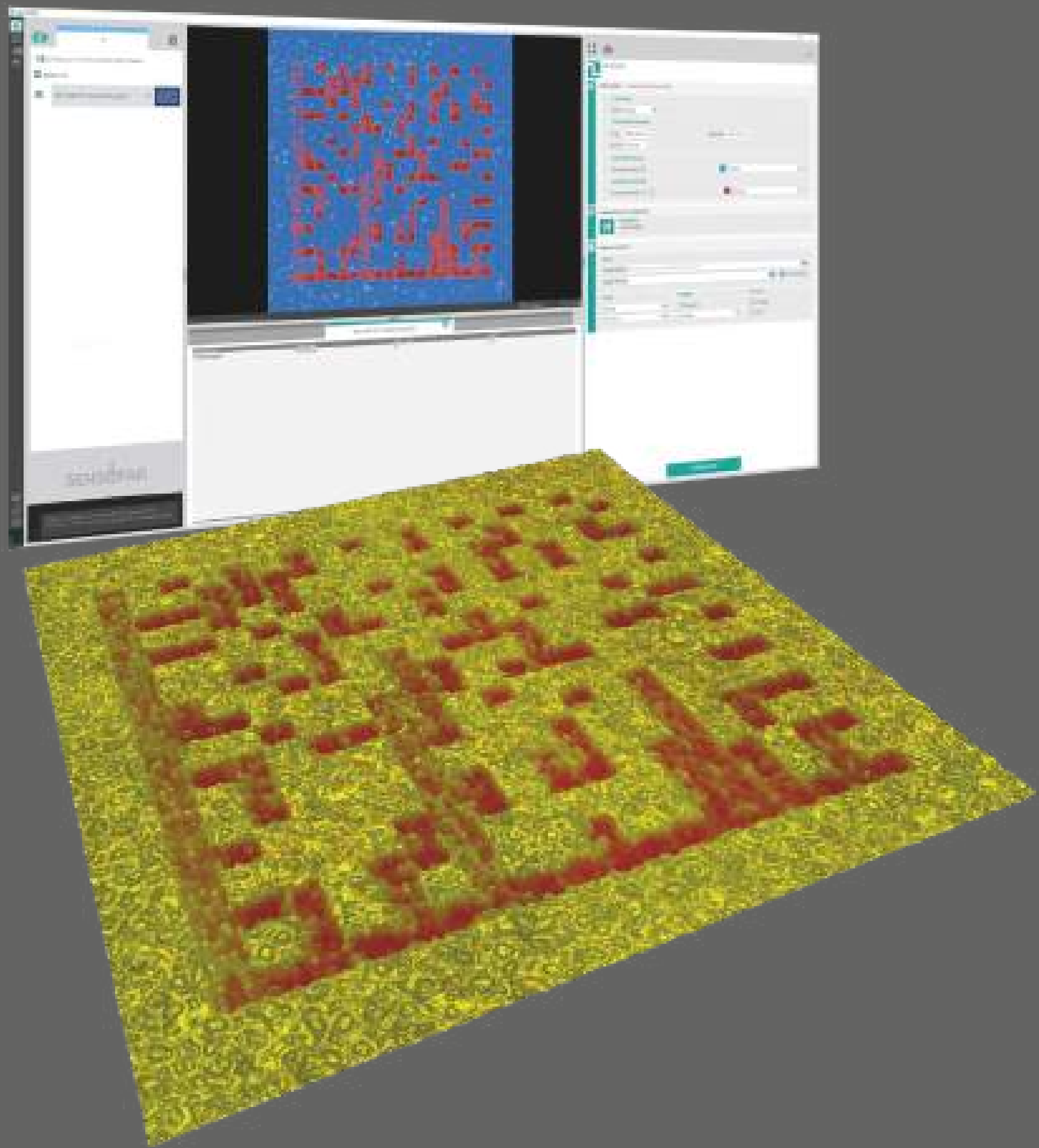
HOW CAN WE HELP?

Barcode engraving assessment

Barcode engraving is used for identification purposes on battery cells or modules. However, it can also cause damage to metal surfaces if done improperly or excessively. Sensofar's optical profilers can use Fringe Projection techniques to measure barcode engraving quality by analyzing parameters such as depth, width, and edge sharpness. These measurements can help optimize laser parameters and prevent over-engraving or under-engraving issues.



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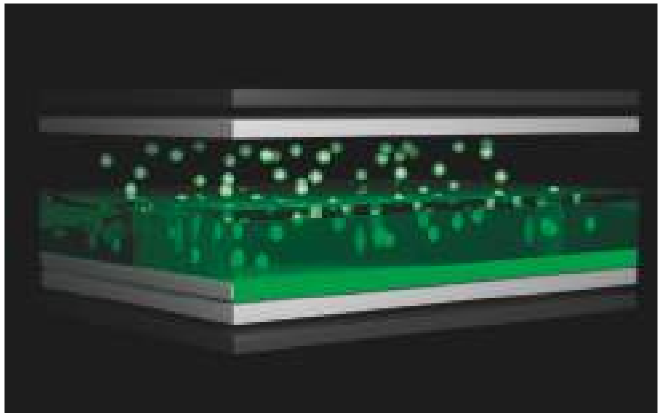
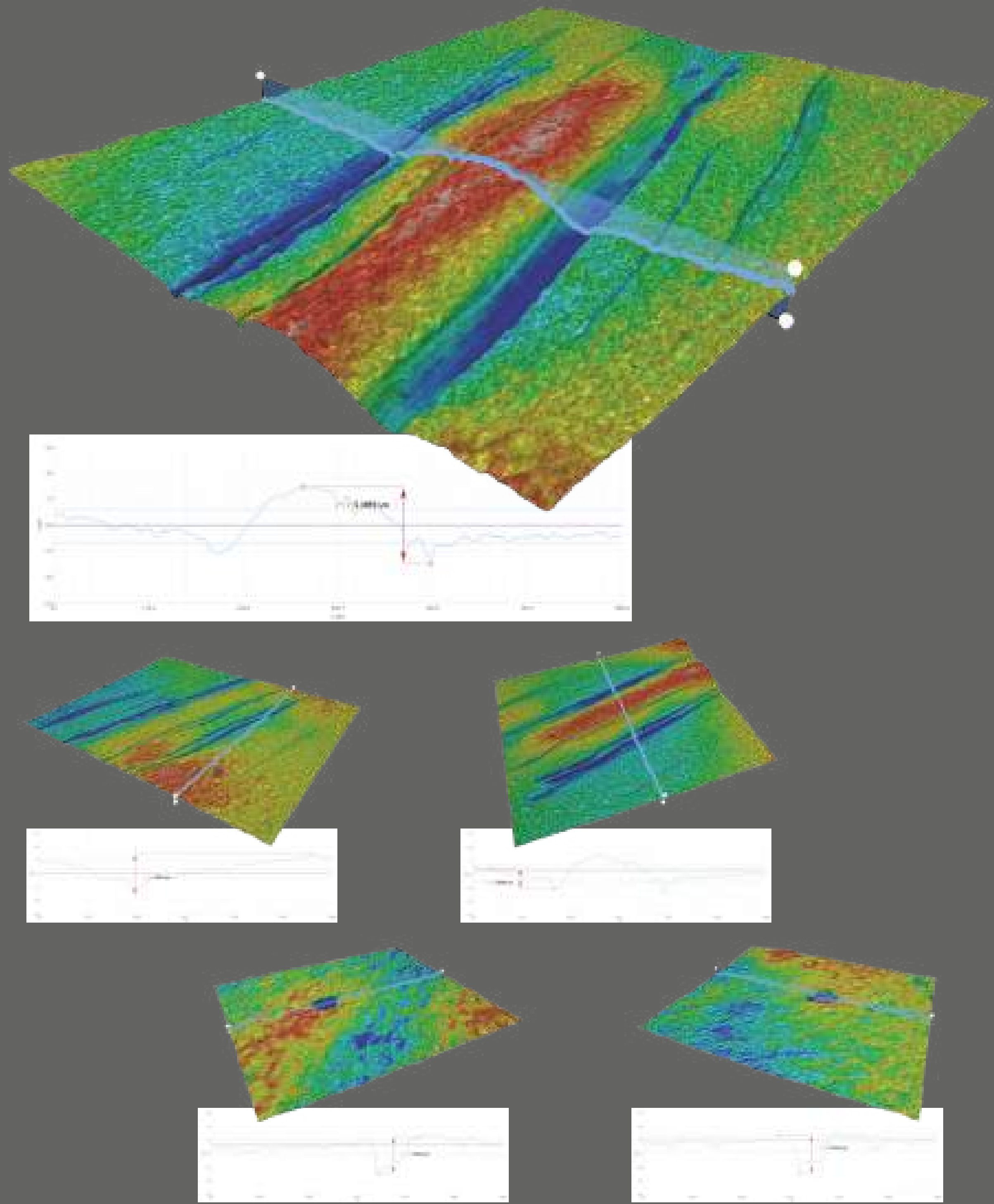
HOW CAN WE HELP?

Battery separator defect inspection

The primary safety element of a cell is the battery separator, which prevents direct contact between the two electrodes responsible for the flow of electrons during the operation of the battery. Lithium-ion cells are demanded to have a high energy density in EVs, which can be partially achieved using thinner separators. In this scenario, these flat, porous membranes must be the highest quality possible and defect-free. Optical areal measurements help to assess whether the irregularities on the surface of battery separators will or will not impact the overall performance and safety of the battery.





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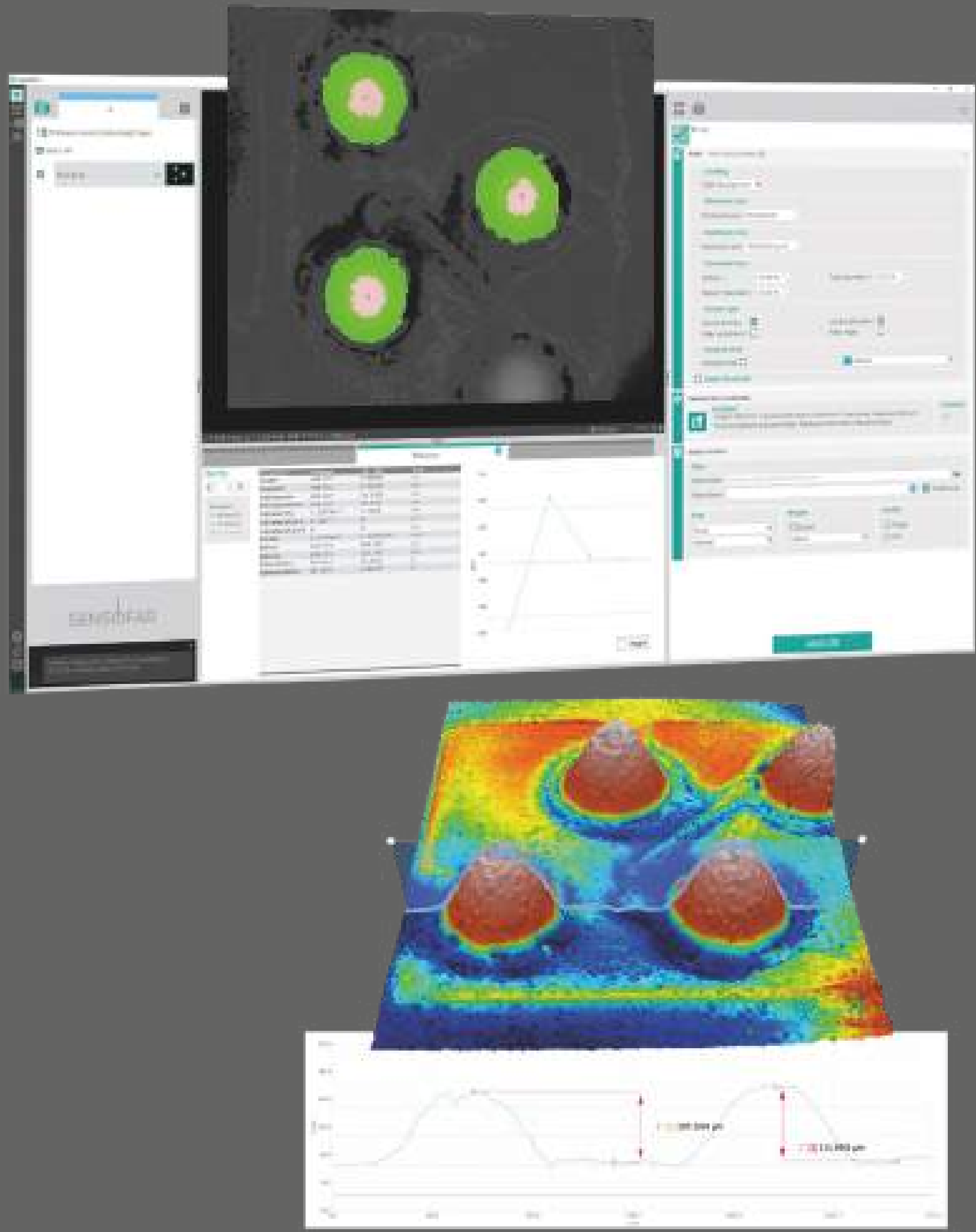
HOW CAN WE HELP?

Coplanarity of BGA

Ball Grid Array (BGA) is an electronic packaging technology that utilizes solder balls to establish electrical connections between components and circuit boards. In the context of SiP batteries, it helps to save space. Optical characterization can assess the uniformity of BGA pin heights, which is a crucial factor in determining connection reliability. The most critical parameter is coplanarity, which calculates the differences between average and individual bump heights, providing valuable insights into connection quality.



CONCLUSIONS

Quality control and accurate measurements are critical for new and repaired EV batteries. Using Sensofar's solutions for quality control of batteries for electric vehicles, you can ensure that your batteries meet high performance, safety, and durability standards. You can also reduce waste, cost, and process time by avoiding rework, scrap, or recalls due to defective batteries.

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Improved performance

By controlling roughness during battery production, manufacturers can improve key performance indicators such as Capacity Retention Rate (CRR), Cycle Life Span (CLS), Power Density (PD), or Energy Density (ED).

Enhanced safety

Having an accurate roughness control in the production environment can also help, manufacturers can reduce safety risks such as Thermal Runaway (TR), Short Circuit (SC), or Fire Explosion (FE).

Reduced costs

Manufacturers can save costs by controlling surface finish and flatness during battery production since they would be reducing waste materials, rework operations, and warranty claims. Furthermore, metrological characterization allows for reintroducing repaired batteries to the market.

Sensofar displays a comprehensive range of solutions to meet the characterization needs of Electric Vehicles batteries manufacturing and repair processes, offering endless possibilities.

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METROLOGY

SENSOFAR is a leading-edge technology company that has the highest quality standards within the field of surface metrology

Sensofar provides high-accuracy optical profilers based on confocal, interferometry, and focus variation techniques, from standard setups for R&D and quality inspection laboratories to complete non-contact metrology solutions for in-line production processes. The Sensofar Group has its headquarters in Barcelona, a European technology and innovation hub. The Group is represented in over 30 countries through a global network of partners and has its own offices in Asia, Germany, and the United States.

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