LMI TECHNOLOGIES

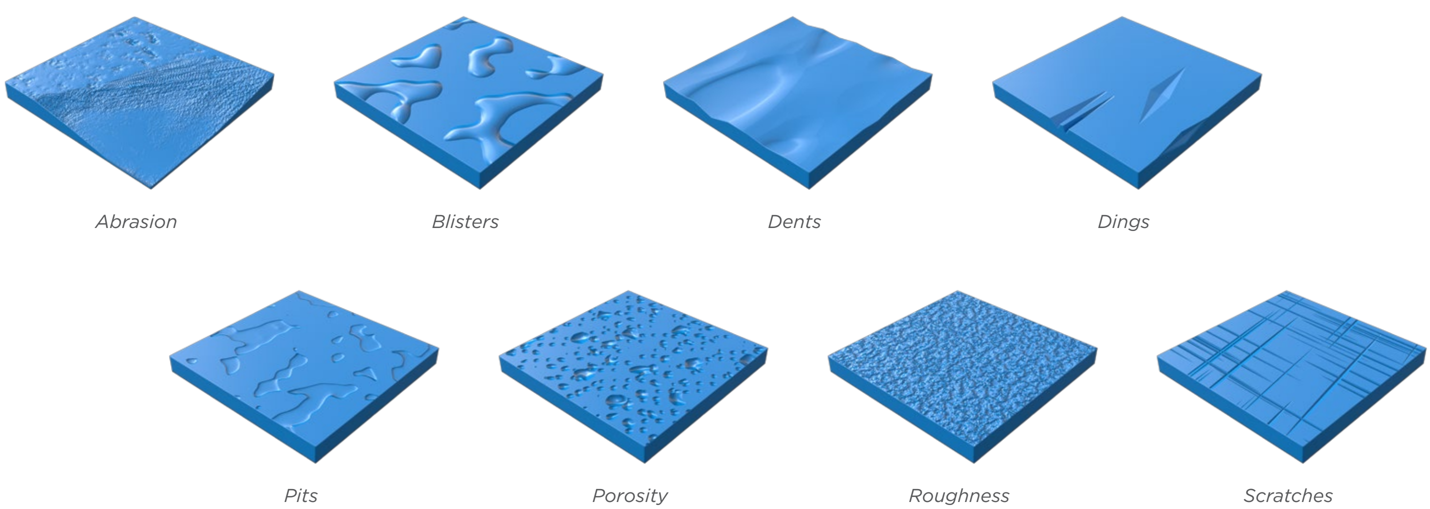
SOLVING THE CHALLENGES OF SURFACE INSPECTION WITH 3D SMART SENSORS

AN INTRODUCTION TO SURFACE INSPECTION

Ensuring Finished Product Quality
Surface inspection is a vital quality control step for many industries, including consumer electronics (CE), automotive, paper, road, and factory automation. This late-stage inspection task ensures products are properly finished and ready for distribution. Since even the smallest surface flaws can impact finished product aesthetics and performance, inspection requires a high degree of accuracy and reliability.

Identifying a Wide Range of Defects
In order to provide robust product grading, surface inspection systems must be able to recognize and execute control decisions (pass/fail) on a wide range of characteristics including porosity, abrasions, splits, rust, scores, and discoloration. Common industrial materials that require inspection of surface characteristics include glass, plastic, stamped metal, cast metal, and machined metal.

Automated surface inspection involves the identification of features that deviate from the specified component tolerance.



Common surface characteristics that impact finished product quality

COMMON INSPECTION CHALLENGES

Manual Inspection Is Limited
Most surface inspection today is carried out either by Coordinate Measurement Machine (CMM) or human technician. CMMs are highly accurate but too slow and expensive for use in high-speed inline processes. Manual inspection is satisfactory at identifying gross defects, but poor at micron-level feature recognition. Manual inspection also falls short when quantifying (i.e., measuring) the defect is required.

Additional Challenges

- Fast production rates demand high-speed quality control
- Subtle variations in light uniformity affect results
- Presence of products with complex shapes requires maximum scan coverage

Material Surface Variation
Material surface properties vary dramatically from industry to industry—everything from low-contrast, black-on-black rubber surfaces to highly reflective or transparent materials such as glass or plastic. Therefore, an effective inspection solution must produce accurate scans suitable to measure surface characteristics despite a large variation in material albedo and texture.

Defect Type and Location
Surface defects occur in a wide variety of shapes and locations on the part. This poses a significant challenge to 100% quality control because there is no single standard measurement approach that can segment and identify the wide spectrum of possible surface markings.

Defects That Fall Within Geometrical Tolerances
Surface defect detection is carried out by comparing a scanned part to a CAD model to identify whether the feature is within tolerance. Some surface defects, however, have a height/depth that is smaller than the geometrical tolerance of the region of interest (ROI). Defects that are smaller than the geometric tolerance will escape detection.

THE 3D SOLUTION

Automated Non-Contact Inspection
3D smart sensors automate what was once a manual task and produce repeatable metrics to help better understand surface quality. Non-contact sensors are non-destructive to surface materials, produce highly accurate and repeatable surface measurement, and are able to match inline production speed.

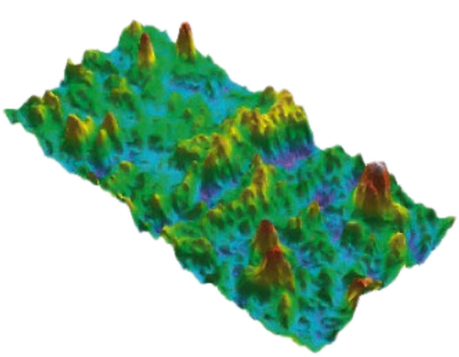
Handles Many Surface Material Types
3D smart sensors offer several exposure methods and data processing algorithms designed to handle shiny surfaces (e.g., small electronic parts) and low-contrast surfaces (e.g., tire tread and sidewall).

Highly Repeatable Defect Identification and Analysis
3D smart sensors have built-in capabilities for anchoring and part matching to ensure the same location is being inspected on every part that passes on the conveyor, regardless of variation in part position.

High Resolution for Identifying Sub-Tolerance Defects
3D smart sensors deliver micron-level inspection of surface features at inline speed. For even greater precision, factories can move specific parts into offline work cells, at designated points midstream on the production line, in order to carry out sub-micron surface analysis using metrology-grade 3D technology (e.g., structured light scanners).

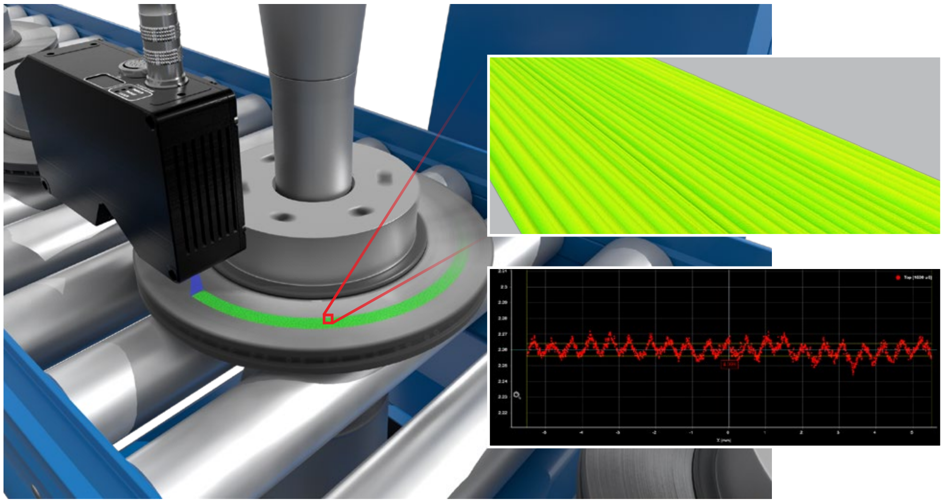
Profile Line vs. Area Roughness Parameters

Roughness is a common measurement in surface inspection. In the CMM world, Roughness Parameters are defined in the ISO 4287 (Ra) standard, which is a set of values based on profile lines. Optical systems such as 3D smart sensors, however, use the ISO 25178 (Sa) standard. Sa parameters are based on surface roughness calculated over an area. This distinction is important because optical systems that reference area-based parameters are faster than contact-based methods that reference profile line parameters (i.e., CMMs)—and are therefore better suited to inline surface inspection applications.

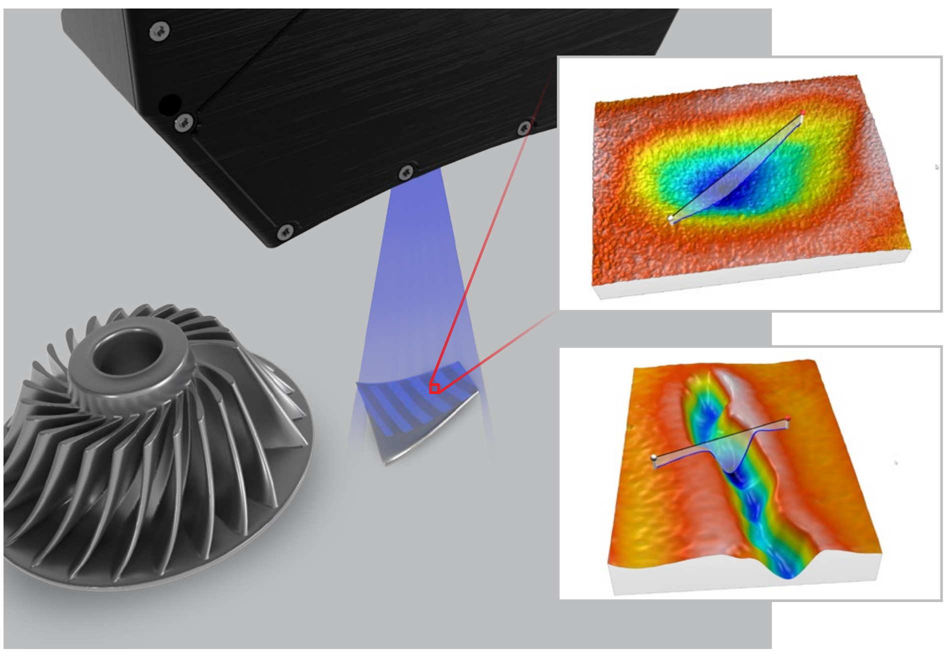


ISO 25178 Height Parameters			
Sq	0.0937	mm	Root-mean-square height
Ssk	1.25		Skewness
Sku	6.22		Kurtosis
Sp	0.502	mm	Maximum peak height
Sv	0.289	mm	Maximum pit height
Sz	0.791	mm	Maximum height
Sa	0.0697	mm	Arithmetical mean height

APPLICATION EXAMPLES



Inline inspection of brake rotors down to 1.1 µm Z resolution. Maximum and minimum height are measured, and an average is calculated to determine the acceptable surface finish.



A 3D scanner identifies two defects [scratch (left), and pit (right)] on an airplane turbine blade.

Analyzing Surface Texture

The majority of surface inspection involves analyzing medium-wavelength surface texture (i.e., roughness and waviness). For surface analysis to take place, however, short-wavelength (i.e., microroughness) and long-wavelength (i.e., form) surface textures must first be removed by mechanical processes.

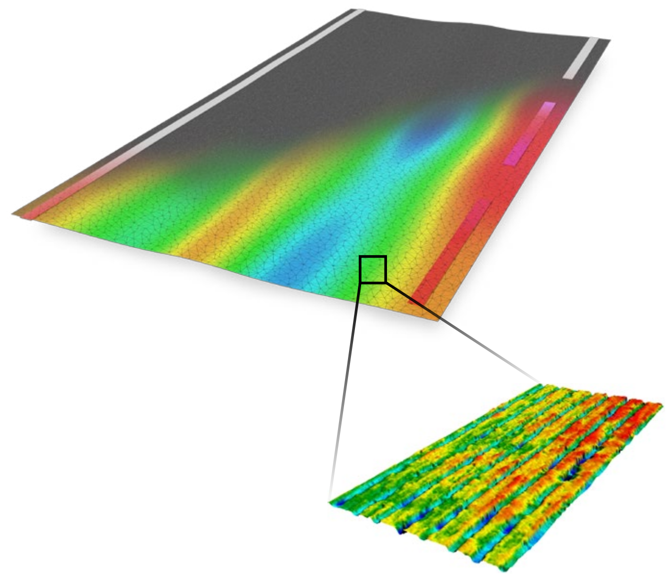
INDUSTRY SPOTLIGHT: ROAD & AUTOMOTIVE

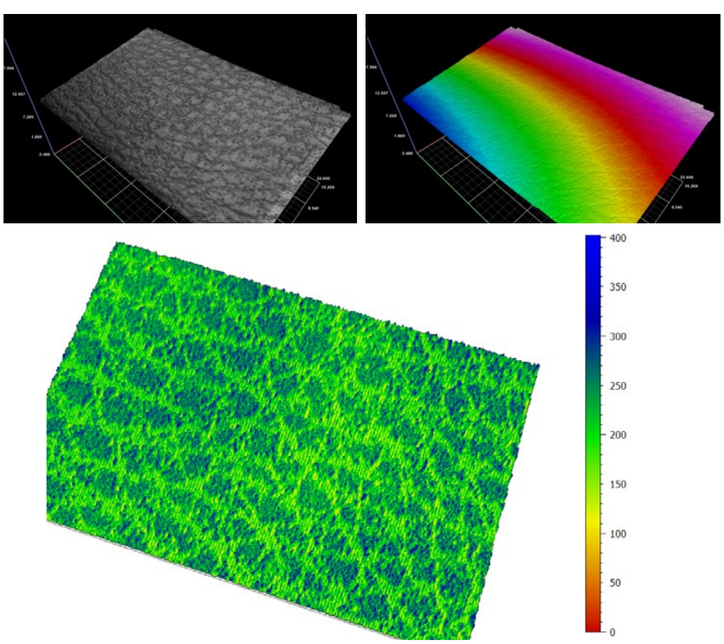
Road Surface Analysis

Road surface inspection requires high-speed, high-precision data to measure pavement characteristics such as roughness, aging, ravelling, sags and humps, corrugation and waves, rutting, patching, and road edge conditions. Data is communicated to technicians to identify which stretches of pavement require re-paving or crack sealant within the next 12 months.

3D smart sensors provide several important advantages in road applications:

» High-speed, continuous pavement scanning saves time
» Multi-sensor networking allows for the scalability required to scan entire lane width
» Dynamic exposure delivers accurate scanning of road markings even in direct sunlight





3D smart sensors used to analyze the surface finish of a car dashboard. Heightmap, intensity, and detailed surface roughness data outputs are shown.

Automotive Interior Inspection

The visual and tactile characteristics of automotive interior surfaces are important to consumer satisfaction and overall quality control. For this application, 3D smart sensors are used to inspect the surface of plastic moldings such as dashboards, inside door panels, consoles, and seats—ensuring correct surface finish down to the micron-level.

FINISHED TO PERFECTION

Achieving 100% Quality Control with 3D Smart Sensors

Easy-to-Use
Features such as web-browser driven point-and-click environment for rapid configuration, built-in measurement tools, and rich I/O for communicating results make it easy for factory technicians to get the results they need.

Low Latency
Real-time measurement capabilities mean factories can consistently meet their throughput targets. Low latency is also important for triggering output actions in real-time (e.g., eject gate for sorting failed parts).

Non-Contact
Laser profilers and structured light snapshot sensors leverage proven 3D technologies to meet the challenges of inline quality control.

Metrology-Grade
3D sensors based on laser triangulation and structured light can achieve resolutions down to 1-2 microns in Z and 5-10 microns in X and Y, matching the typical performance of lab-based CMM machines.

Flexible I/O
3D smart sensors provide a wide variety of outputs to communicate results directly to PLCs and execute timely, accurate control decisions.

Connected
Today's 3D smart sensors connect seamlessly with factory infrastructure to report measurement results, monitor trends from a web browser, upgrade sensors over the Internet, or network with other machinery to exchange or combine data.

WHY SMART 3D?

- Volumetric measurement (X, Y, and Z axis), providing shape and position related parameters—necessary for robot handling
- Contrast invariant, ideal for inspecting low-contrast objects
- Immune to lighting variation and ambient light
- Higher repeatability due to integrated optics, lighting, and pre-calibration
- Simpler to build multi-sensor setups for large object inspection

IT'S BETTER TO BE SMART
contact@lmi3d.com

ABOUT LMI TECHNOLOGIES
ADVANCING QUALITY AND PRODUCTIVITY WITH SMART SENSOR TECHNOLOGY

LMI Technologies advances quality and productivity with award-winning sensors that power FactorySmart® 3D inspection systems in the factory. Visit www.lmi3d.com or email contact@lmi3d.com for more information.

AMERICAS
LMI Technologies Inc.
Burnaby, BC, Canada

EMEAR
LMI Technologies GmbH
Teltow/Berlin, Germany

ASIA PACIFIC
LMI (Shanghai) Trading Co., Ltd.
Shanghai, China

LMI Technologies has offices worldwide. All contact information is listed at lmi3D.com/contact

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