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LMI TECHNOLOGIES

FactorySmart® Inspection

SEMICONDUCTOR QUALITY INSPECTION

WITH FOCALSPEC® LINE CONFOCAL SENSORS

FocalSpec® LCI1220

Semiconductor fabrication is a multi-step manufacturing sequence made up of mechanical, photolithographic, and chemical processing steps, during which electronic circuits are gradually created on a wafer made of pure semiconducting material. Silicon is almost always used, but various compound semiconductors are chosen for specialized applications.

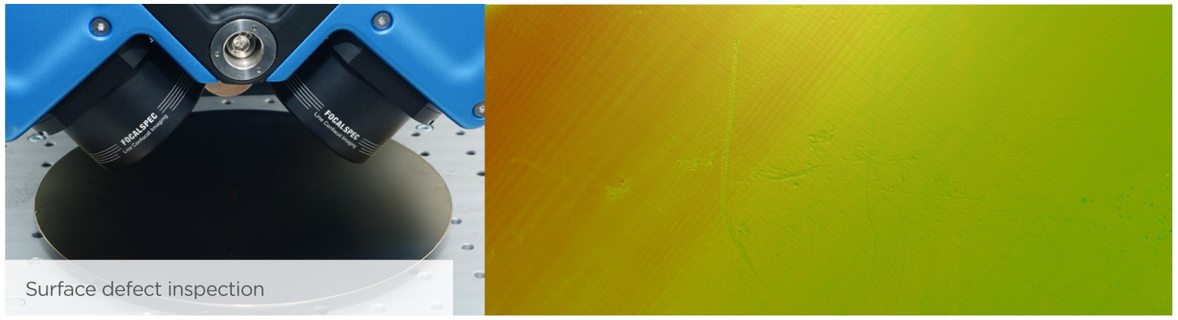
FocalSpec® 3D Line Confocal Sensors deliver precision inline 3D scanning and inspection at various stages of this fabrication process for maximum product quality and optimal production throughput.

THE SEMICONDUCTOR FABRICATION PROCESS

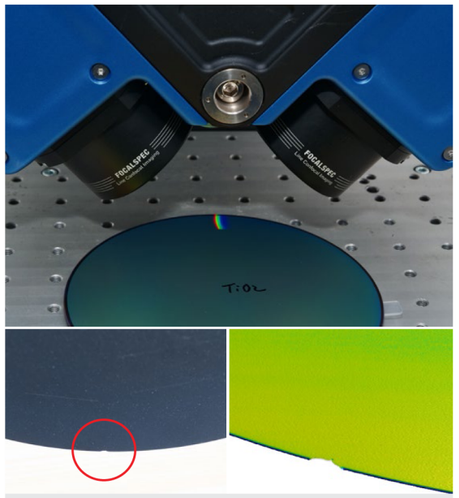
1. Wafer sorting

Wafers are sorted into separate types according to specified characteristics. This classification process requires 100% quality control of silicon wafer shape, length, width, thickness, and surface defects.

FocalSpec® 3D Line Confocal Sensors are used to scan and inspect wafer size, thickness, and flatness, in addition to providing high-precision defect detection.



Surface defect inspection



Die chipping inspection

1.1 Wafer polishing pad inspection

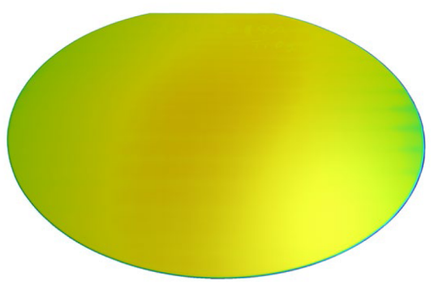
Wafer polishing pads play an important role in the balance of the chemical-mechanical polishing (CMP) process. Over time, these pads begin to show wear and need to be inspected regularly as part of the production line's machine-monitoring protocol.

Focalspec® 3D Line Confocal Sensors can be used to scan the surface of the wafer pad, identifying any potential variation in 3D height data that would indicate areas of such wear.

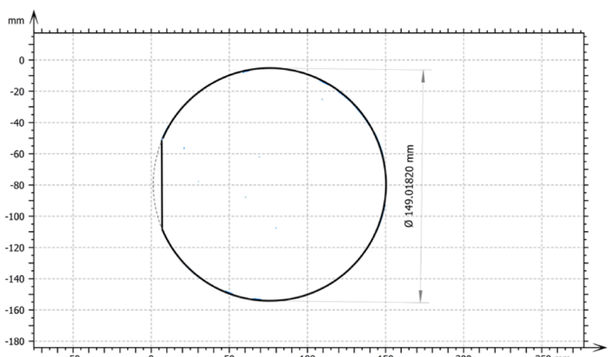
2. Wafer dimensional measurement and defect detection after scribing

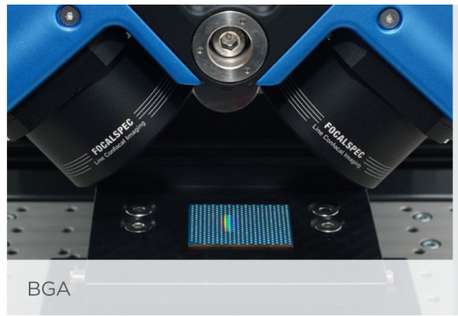
Scribing is one type of die singulation technique where the wafer or substrate is partially cut through by a process tool (such as a laser or saw blade), and then divided into individual die by a subsequent "breaking" step that separates the wafer along the scribed lines. This manufacturing process requires 100% surface inspection of the die to ensure accurate wafer cutting.

After laser dicing and/or scribing is complete, **FocalSpec® 3D line confocal sensors** are used to measure the accuracy of the groove placement, groove depth, and kerf width of the wafer scribing to prevent defects such as die chipping. This allows for more usable die per wafer, and ensures maximum quality and processing speeds for the highest production throughput.

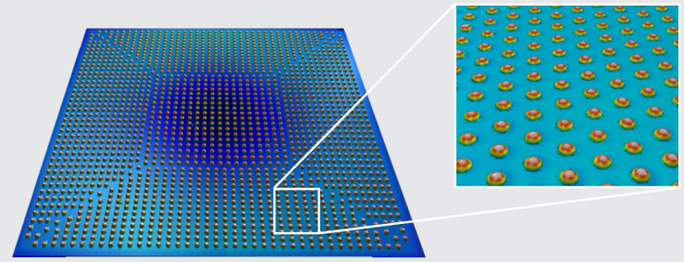


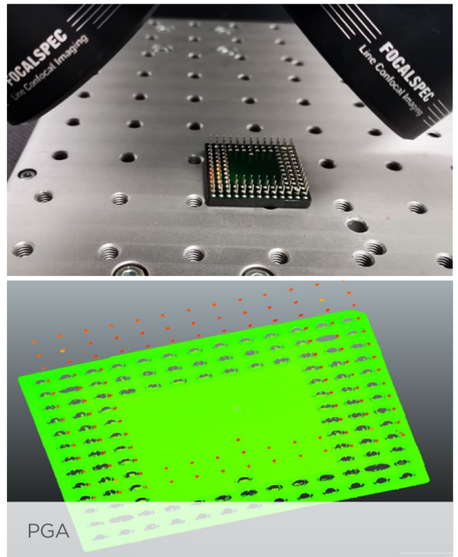
Dimensional Measurement





BGA





PGA

3. Inspection of BGA and PGA position, height, and radius during assembly and test IC

BGA

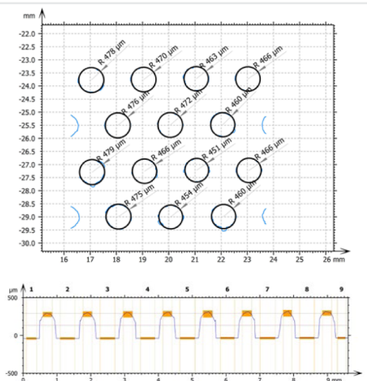
The BGA (Ball Grid Array) chip is a typical integrated circuit (IC) chip that uses SMT (Surface Mount Technology) to deliver high-density connectivity. BGA balls are distributed on the bottom surface of the chip, so the number of balls can be increased while the chip volume remains unchanged. With the increasing use of BGA pins in semiconductor production, inspection of pin height, diameter, offset, and missing solder is required.

FocalSpec® 3D Line Confocal Sensors can accurately measure ball height, ball position, and other dimensional information of the ball with a diameter of less than 50 µm.

PGA

PGAs (Pin Grid Array) consist of multiple square matrix pins located inside and outside the chip, where each square matrix pin is arranged at a certain distance along the periphery. According to the number of pins, the PGA can be enclosed in 2 to 5 circles. Compared with BGAs, PGAs are larger, but easier to replace, with some of the operational errors that occur during replacement falling within acceptable tolerance.

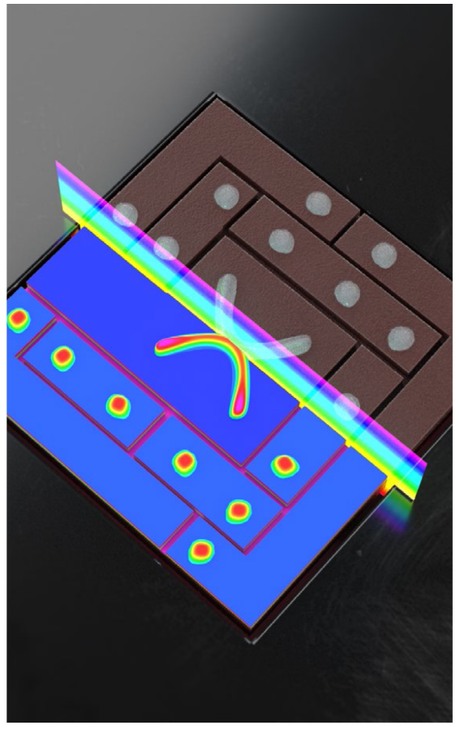
FocalSpec® 3D Line Confocal Sensors can accurately inspect the height and position of the PGA pins to ensure that there are no poor contacts created during the subsequent insertion and removal process, and to prevent defects such as pin damage caused by positional errors.

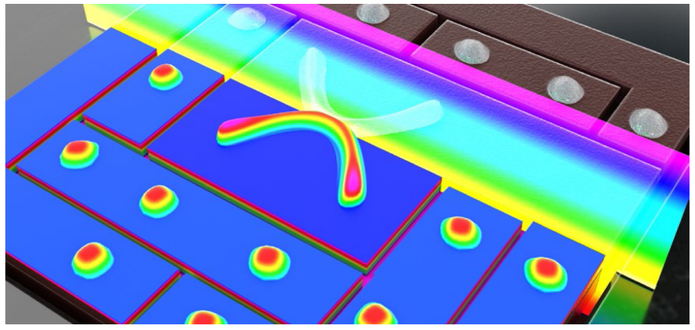


Differential in the thermal expansion coefficient of the PCB substrate and the BGA package can cause breakage of the solder joints due to bending (thermal stress), or stretching and vibration (mechanical stress).

FocalSpec® 3D Line Confocal Sensors can accurately measure and inspect the flatness and height of joint position before welding, then it can reduce the breakage of each solder joint after subsequent welding is completed.

Parameters	Unit	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9
Width	mm	0.299	0.440	0.440	0.435	0.446	0.419	0.457	0.440	0.245
Maximum depth	µm	334	334	333	332	330	329	329	327	327
Mean depth	µm	334	333	332	331	329	328	328	327	326



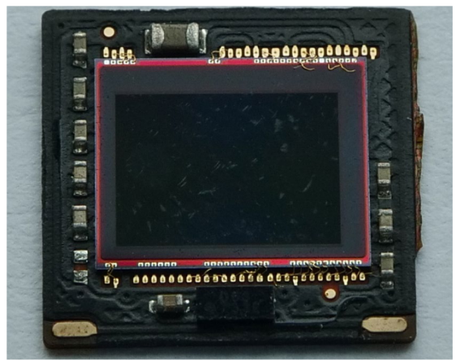


4. Inspection of silver epoxy during die application

Die adhesives, like silver epoxy, attach the die to the die pad, substrate, or cavity. They also provide thermal and/or electrical conductivity between the die and the package, which affects the performance of the device while operating in the field. Silver epoxies are commonly used because they are a low temperature cure, high-strength polymer adhesive that allows for quick one-step, curing with minimal stress to the die.

Focalspec® 3D Line Confocal Sensors are used to accurately measure the surface area of coated silver epoxy in each lead frame area, as well as the height (i.e. thickness) of the epoxy glue bead. These sensors generate the essential 3D shape data required for precision volumetric measurement and shape-based defect detection (e.g. bubbles, thickness) on the glue bead.

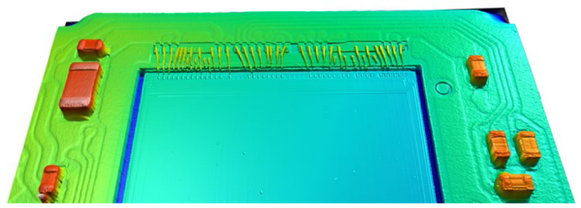
In addition, 3D imaging is contrast-invariant and can therefore be used to scan a range of adhesive material types from opaque to translucent and transparent. In comparison, 2D solutions cannot provide shape measurements because they only generate contrast-based data.

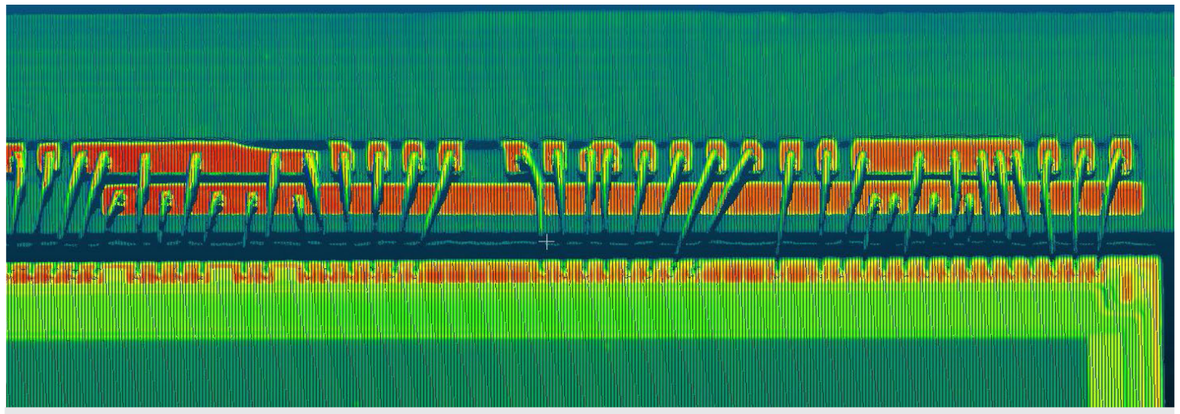


5. Defect inspection during wire bonding process

Wire bonding is also called microwelding or pressure welding. It is typically a thermo-ultrasonic bonding process, using heat and ultrasonic waves, under the combined action of pressure, heat, and ultrasonic energy, to weld the wire to the pads and the lead frame or substrate. The purpose of this process is to form a high quality ohmic contact between the electrode and the outer lead bonding area in order to provide high-performance connectivity between the chip and pins.

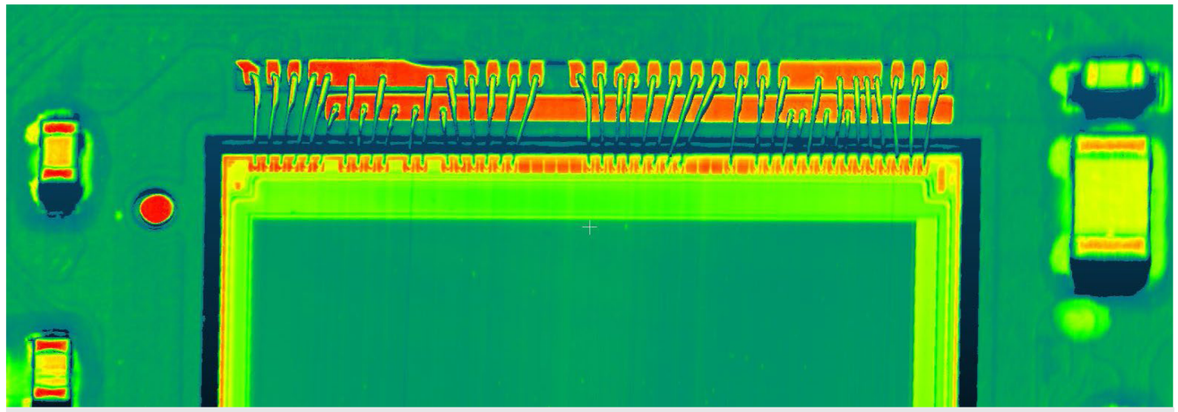
FocalSpec® 3D Line Confocal Sensors are used for high accuracy measurement of the arch-height and position of the wire (gold, copper, or aluminum). In addition, line confocal sensors can detect defects, such as breaks or bends in the wire.



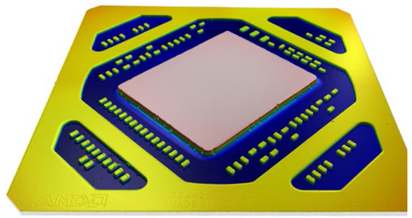


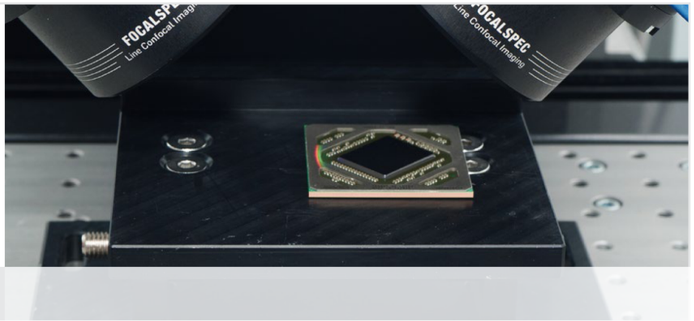
6. Dimensional measurement during ball-bumping process

In the ball-bumping process, instead of making the second connection with a wire loop and stitch (i.e., wire bonding), the wire is removed after the ball is connected to the die. A new ball is formed and the process repeats as necessary on all the die bond pads.

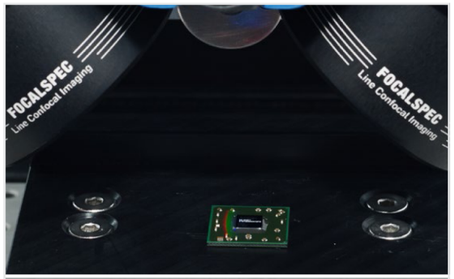


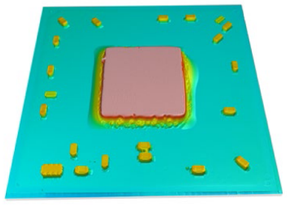
At this stage, **FocalSpec® 3D Line Confocal Sensors** accurately capture the diameter and height (thickness) of the ball down to 2.5 microns. The sensors are also used to inspect the coplanarity between all ball bumps—detecting any height variation that can cause uneven distribution of force, die fractures, and open circuits.





Dimension inspection after packaging



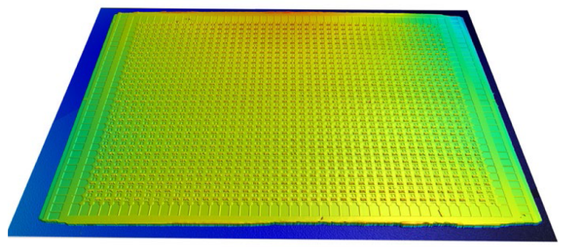


7. Dimensional measurement and defect inspection after final packaging

FocalSpec® 3D Line Confocal Sensors can capture the length, width, and height of the chip after final packaging. FocalSpec sensors can also output high-resolution 2D grayscale images to detect defects such as pits and scratches.

Key sensor capabilities

- Simultaneous acquisition of 3D, 2D and tomographic data
- Works well on highly reflective, mirror-like, transparent and multilayered surfaces
- Resolution: down to 2.1 µm (x), 0.05 µm (z)
- Measurement range: up to 5.5 mm (z)
- Acquisition rate: up to 28 million 3D and 2D data points per second per surface
- Scan time for area equal to 300 mm wafer at 6.7 µm by 6.7 µm spatial resolution: 1 minute



Touch chip inspection

FocalSpec®

Additional applications solved

- ✓ Patterned wafer broad range inspection
- ✓ Multi-substrate defect inspection and metrology
- ✓ Advanced surface inspection of compound semiconductor materials
- ✓ Defect inspection on SiC and GaN substrates
- ✓ Hard disk drive media and substrates defect inspection, topography measurement, and classification
- ✓ High throughput defect inspection for large and irregular shaped substrates
- ✓ Inline flat panel temperature monitoring
- ✓ Unpatterned wafer flatness measurement
- ✓ Wafer warp/bow inspection
- ✓ Wafer edge roll-off inspection
- ✓ Wafer edge geometry measurement and defect detection
- ✓ Sub-micron (i.e. deep) surface defect detection
- ✓ Global and local wafer topography measurement

LCI1220

LCI1620

LCI1600

Application Summary

Semiconductor manufacturing is a complex multi-step process that requires 100% quality inspection. Contact methods of inspection, such as manual quality control or the use of CMMs, are prone to error and or damaging of the semiconductor materials.

Conclusion

Non contact 3D line confocal technologies provide manufacturers with a non-contact, high performance, and scalable solution for precision 3D inspection of challenging semiconductor materials, components, and assemblies.