

OptiCon X-Line 3D

Combined 3D X-ray and Optical
Inspection at Production Line Pace



Automated X-Ray Inspection (AXOI)

OptiCon X-Line 3D: AXI and AOI teamed up

High-Speed X-Ray System for Maximum Test Coverage

OptiCon X-Line 3D is an automatic three-dimensional measuring X-ray inspection system for rapid inspection of printed circuit board assemblies. OptiCon X-Line 3D is based on a patent-pending detector concept, which has been developed in-house by GOEPEL electronic. Using a maintenance-free microfocus X-ray tube it allows for real-time multi-angle image capture.

A continuously scanning image acquisition unit provides for high-resolution X-ray images, which are acquired, pre-processed and re-constructed during axis motion. This enables an inspection

throughput of up to 40 cm²/s with full 3D acquisition of the board assembly. Reconstruction procedures based on digital tomosynthesis allow for concurrent inspection of top and bottom sides of assemblies, which are populated on both sides – within a single run. In addition, tomosynthesis allows for distinct analyses of defined board layers and inspection of solder joints with a reliable process. Inspection tasks, which can't be covered by X-ray technology, like polarity checks, character and/or colour recognition, will be addressed by an integrated AOI module.



100 % Test Coverage

Combined AXI and AOI Power

The intelligent combination of automatic X-ray (AXI) and optical (AOI) inspection ensures a close to 100 percent visual test coverage.

X-ray inspection is not only used for **hidden** solder joints, but for **all solder connections** of the entire assembly.

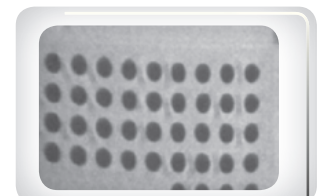
This guarantees a solder joint inspection process, which comes – detached from AOI specific reflections and shadings – extremely close to IPC requirements. Faults like “lifted leads” are reliably detected for all component shapes.

Reliability

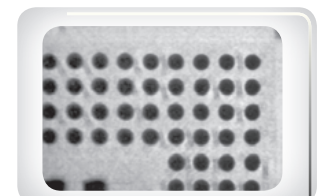
OptiCon X-Line 3D system is completely calibrated relative to geometry and greyscale ensuring stable measuring values. Cyclic monitoring of the calibration status ensures stable image and measurement values.



100 % inspection through AXI + AOI in 41s, including handling



uncalibrated image



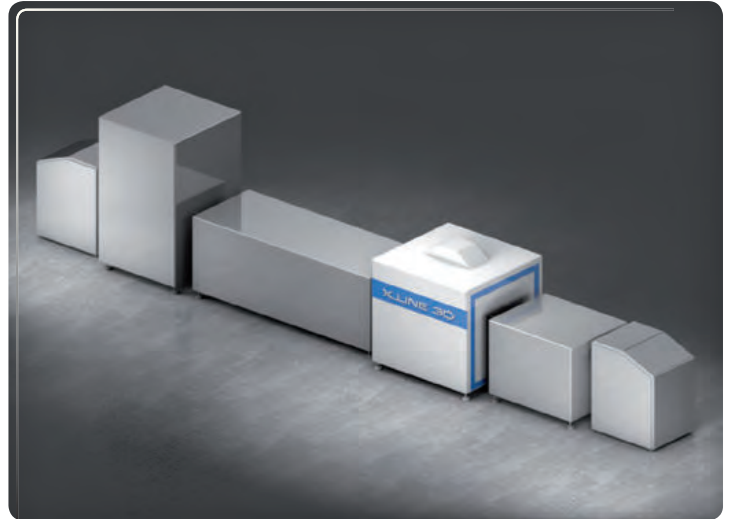
calibrated image

Automated X-Ray Inspection (AXOI)

OptiCon X-Line 3D on the Shop Floor



Stand-alone (off-line operation)



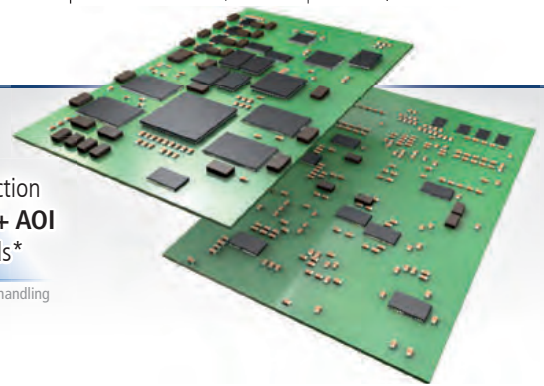
Integrated in the production line (in-line operation)

Inspection example

Board assembly: 160 mm x 100 mm, assembled on both sides
 Components: **509**
 Package styles: 6 x BGA, 20 x SO, 424 x Chip, 12 x THT
 Solder joints: **2977**
 Resolution: 12 µm
 AOI fields of view: 8

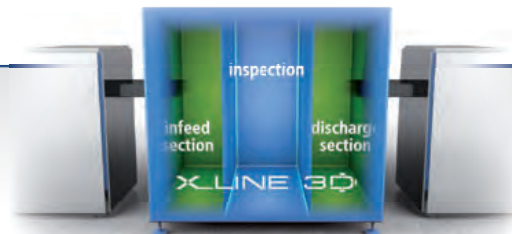
100 % inspection through AXI + AOI in **41** seconds*

*including handling



Board conveyor system

Division of the system in three shielded segments allows for **concurrent operation of board handling and inspection operations.**

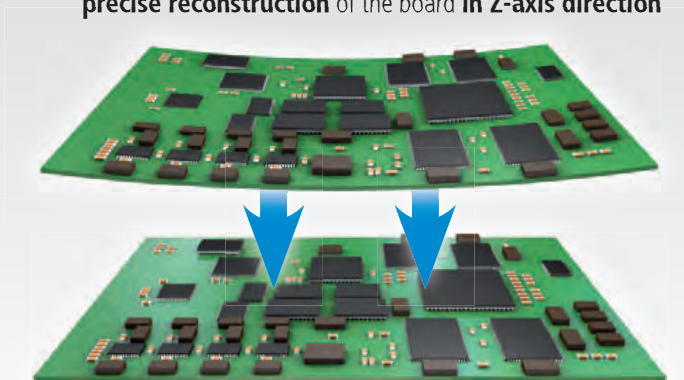


Handling time
5 seconds



Correction of board warpage & stability monitoring

Automatic correction of board warpage allows for **precise reconstruction** of the board **in Z-axis direction**

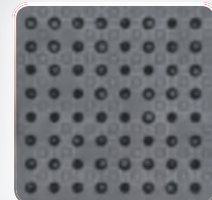


Correction per

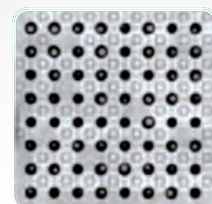
laser height measuring system  and **image stack respectively** 

In addition, all inspection algorithms are automatically referenced to the correct Z-height layer of the solder joint to be inspected

Automated cyclic grey value monitoring ensures stability of **measuring values**



before calibration



after calibration

Automated X-Ray Inspection (AXOI)

X-Ray: 2D, 2.5D & 3D

Maintenance and Safety

The OptiCon X-Line 3D uses a shielded, maintenance-free micro-focus X-ray source and a detector with high service lifetime, in-house-developed by GOEPEL electronic.

Exchanging the X-ray source or the detector is simple and fast – ensuring minimal down time. The compact system captivates through its ext-

raordinary accessibility. Two service hatches and two doors facilitate the access to all important system components. Redundant safety circuits and perfect radiation protection guarantee utmost safety.

The emitted radiation dose is below the detection limit of conventional radiation detectors. Operating the system is therefore totally safe.

3D X-ray Inspection with OptiCon X-Line 3D

Principle of Image Acquisition

The PCB is radiated from at least nine different angles. The resulting images allow for the reconstruction of distinct layers.

Benefits of 3D X-ray Inspection

- safe inspection of PCBs with components on both sides
- reconstruction of arbitrary layers
- spatial assignment of detected faults
- rapid and comfortable inspection programme generation through use of a unified library

Fields of Application

- 3D X-ray inspection in in-line production
- inspection of PCBs with components on both sides
- qualitative inspection of all solder joints (e.g. BGA, QFN)
- check for component presence, offset and shorts
- measurement of voids in different layers
- inspection of complex board assemblies with superimposed soldering layers and assembled heat sinks (integrated power electronics)
- measurement of the hole-fill in THT/THR solder joints
- inspection according to IPC-A-610 requirements

2.5D X-ray Inspection

Principle of Image Acquisition

Superimposed solder joints (e.g. top and bottom side of the assembly) are optically separated in the projections by means of angular radiography.

Disadvantages

- huge programming effort for assemblies with components on both sides due to manual parameter setting for all acquired images
- no unified library available
- long inspection duration

2D X-ray Inspection

Principle of Image Acquisition

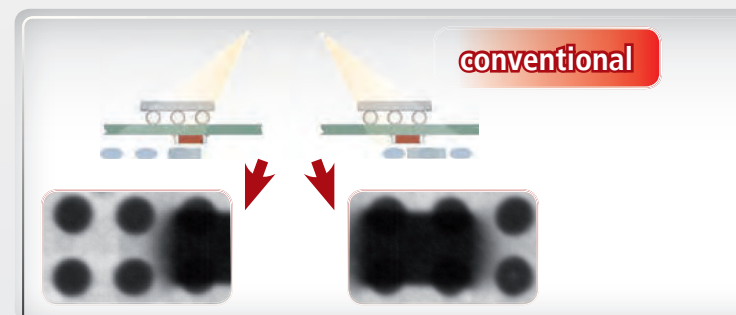
Assemblies are radiated through orthogonally.

Disadvantages

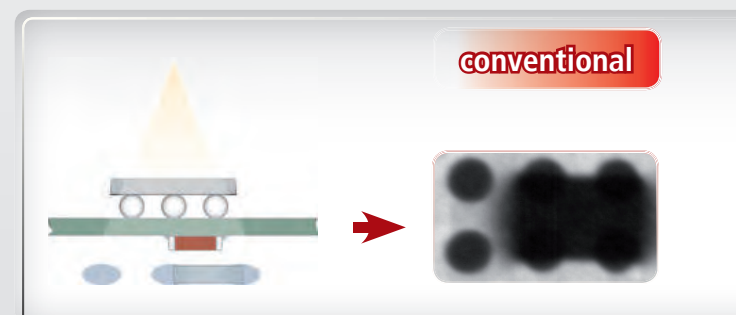
- superimposed solder joints (e.g. top and bottom side of the assembly) can't be inspected
- insufficient information about the quality of BGA solder joints
- no spatial assignment of detected faults



Different projections of a board with components on both sides during 3D X-ray inspection



Optically separated solder joints by means of angular radiography using 2.5D X-ray inspection

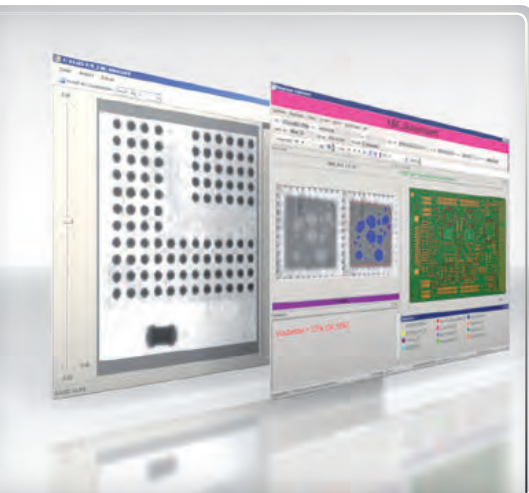


Superimposed solder joints orthogonally radiated through using 2D X-ray inspection

Automated X-Ray Inspection (AXOI) System Software OptiCon XI-PILOT™



OptiCon XI-PILOT software interface



Repair station and analysis software



Statistical evaluation and SPC module



Detection of an un-soldered BGA ball
in various layers of the solder joint

Intelligent Software Concept Raises the Bar – AXI/AOI Programming Featuring the same User Interface

- system software OptiCon XI-PILOT
- off-line programming software
- repair station software
- analysis software
- statistics software
- SPC software



The **OptiCon XI-PILOT** system software is an **open concept** for a **maximum fault-coverage** and optimised adaptation to future component packages and manufacturing requirements. **Automatic X-ray and optical inspections** are programmed using the same user interface. The supplied component library, which complies with IPC standards, is linked with inspection algorithms and serves as the basis for the inspection of all common component packages. The measured values and features extracted by the algorithms will be automatically classified, resulting in **minimum programme generation time**.

Once the initial acquisition of all required X-ray images has been completed, the entire inspection programme generation and library adaptation can be done in the office using **offline programming software**. The **repair station software** features a **vivid visualisation** of detected faults in different representations. Linked to this repair station software there is a powerful **analysis software**, which allows for viewing of all faults of a component in distinct layers. The **statistics software**, equipped with pre-defined filters and the possibility to create user-defined filters, enables the fast detection of main faults as well as an objective evaluation of production quality and throughput. The settable warning and action limits of the **SPC module**, as well as trend analyses allow for taking predictive measures before an actual fault occurs.

Rapid Inspection Programme Generation through Effective use of Libraries

Due to the reconstruction of components and solder joints layer-by-layer, test programme generation and actual inspection processes are executed with geometrically calibrated, distortion free imaging of the actual inspection objects. This enables a rapid and effective inspection programme generation based on CAD data and the use of a component library with pre-defined inspection algorithms and classifiers. Component packages, which are not included in the supplied component library, can be comfortably created using the integrated CAD editor.

Reliable Failure Analysis through Vivid Visualisation

For reliable assessments of detected faults at the **verification** or **repair station**, the original X-ray image of the solder joint will be complemented by an image, which has been analysed by software algorithms and marked with colours. In addition, a **powerful analysis software** is available that aids the user in assessing the fault in different Z layers. The 3D visualisation of selected areas facilitates the vivid presentation of solder joints and components.

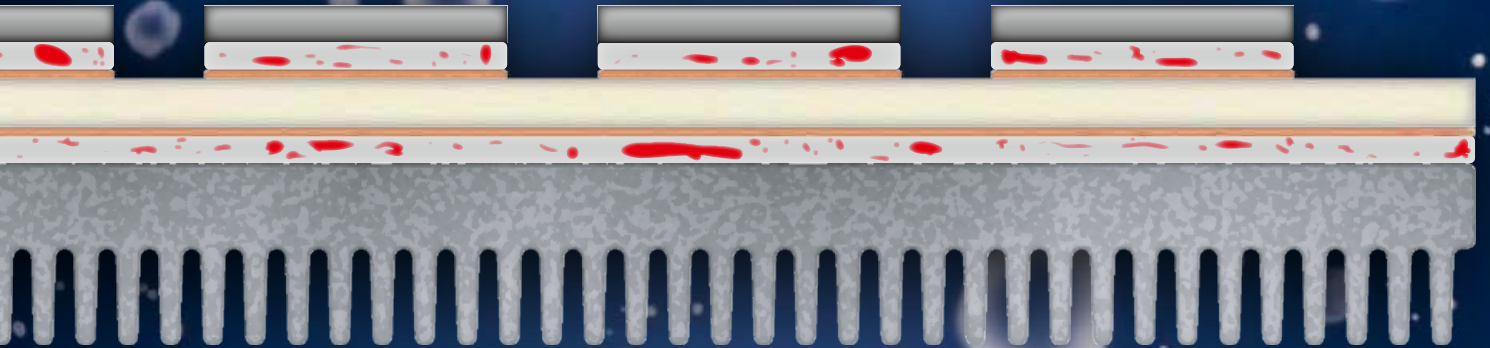
Maximum Fault-Coverage at Outstanding Inspection Speed

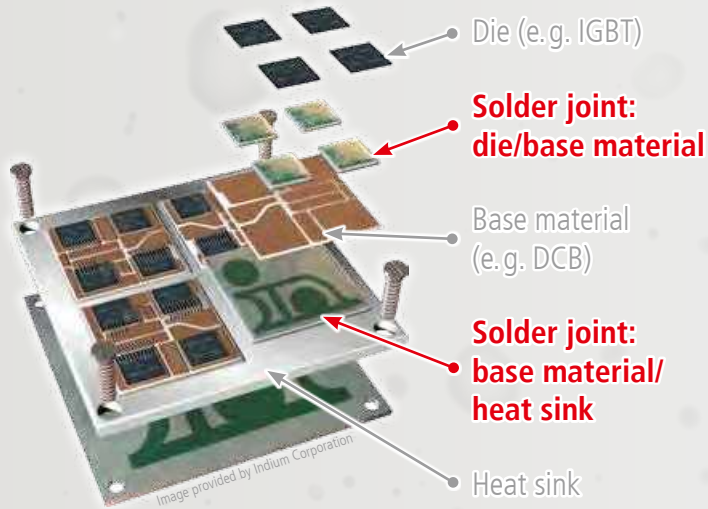
The comprehensive 3D X-ray inspection permits analysis of all solder joints of an assembly layer-by-layer in-line with the line speed. This ensures a reliable detection of critical fault types and the spatial assignment of the recognised faults.



3D Void Inspection

Three-Dimensional X-Ray Inspection for Void Detection





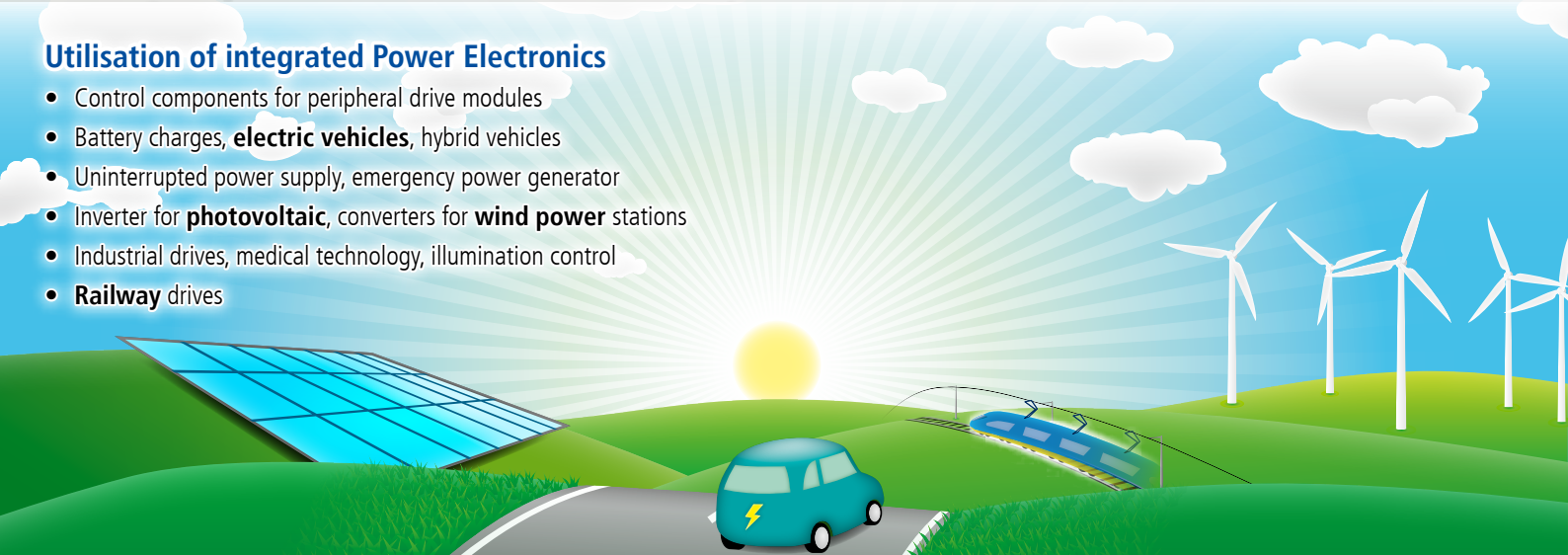
In operation, **integrated power modules** are exposed to **high operating temperatures** and **power density**.

The single elements' (die, ceramic substrates and heat sink) thermal coupling is implemented via **large soldered areas** to ensure the required high efficiency heat transfer.

Voids within these solder joints impede the heat transfer and **are a critical risk** for an assembly's functionality, reliability and durability.

Utilisation of integrated Power Electronics

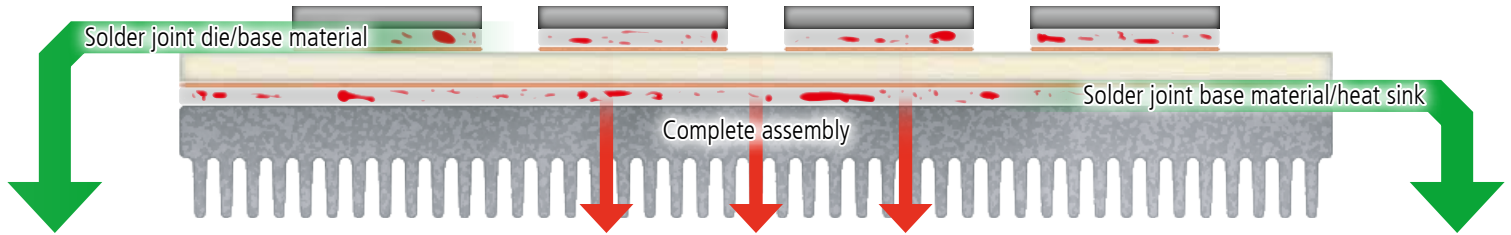
- Control components for peripheral drive modules
- Battery charges, **electric vehicles**, hybrid vehicles
- Uninterrupted power supply, emergency power generator
- Inverter for **photovoltaic**, converters for **wind power** stations
- Industrial drives, medical technology, illumination control
- **Railway** drives



Requirements to the Test Technology

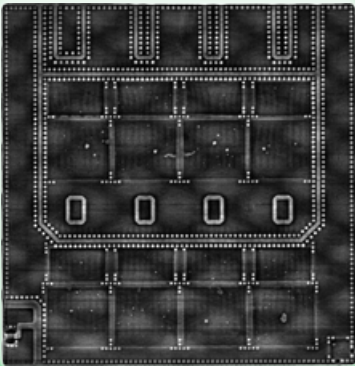
An effective production process meeting the highest quality demands requires a **separated evaluation** of thermal **relevant solder joints** in terms of size and spread of the voids **after all the solder processes** have been completed. The PCB inspections in (partly) mounted state, the utilisation of structured heat sinks of different materials as well as short

production cycles are subjects to the highest demands on the inspection system. **OptiCon X-Line 3D** is an **inline test system**, guaranteeing an efficient quality assurance based on **3D X-ray inspection** with adapted image capturing and reconstruction.



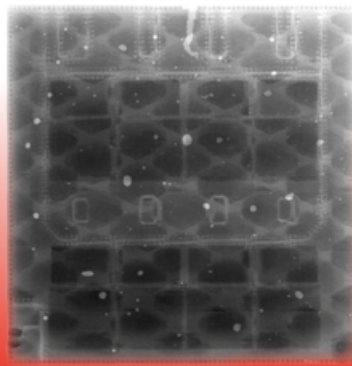
Reconstructed with OptiCon X-Line 3D

- Voids detectable
- Assignment to soldering area possible



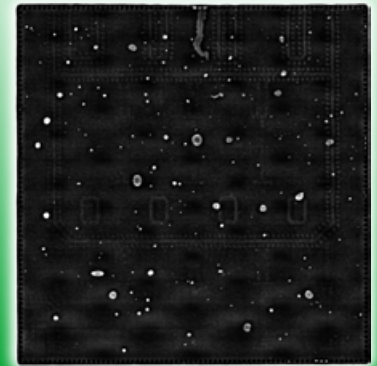
2D/2.5D X-ray inspection

- Voids only partly detectable
- No assignment to soldering area possible



Reconstructed with OptiCon X-Line 3D

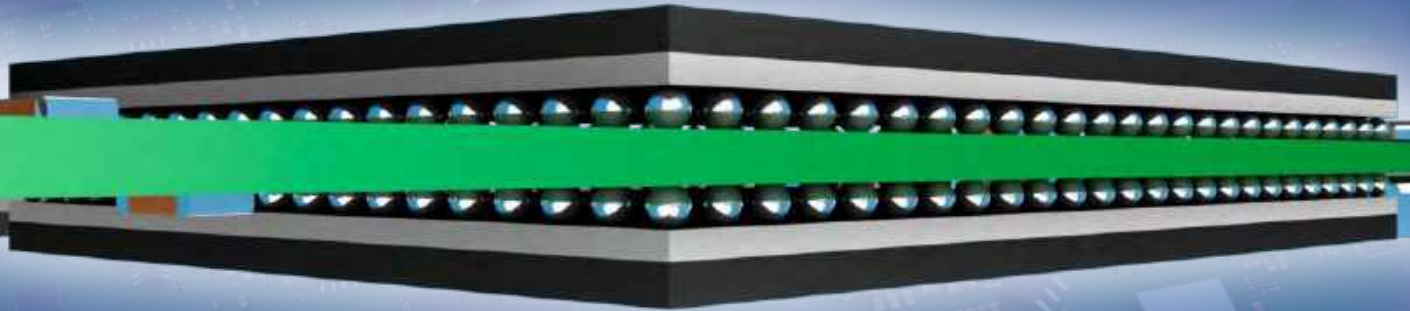
- Voids detectable
- Assignment to soldering area possible





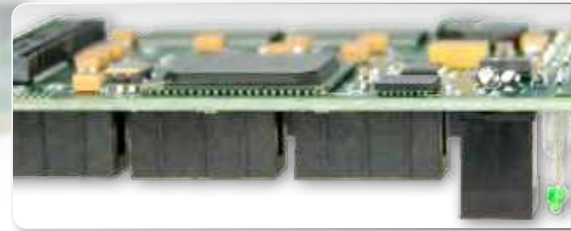
AXI for Double-Sided Equipped PCBs

Safe and Efficient Fault Detection via 3D X-Ray Inspection



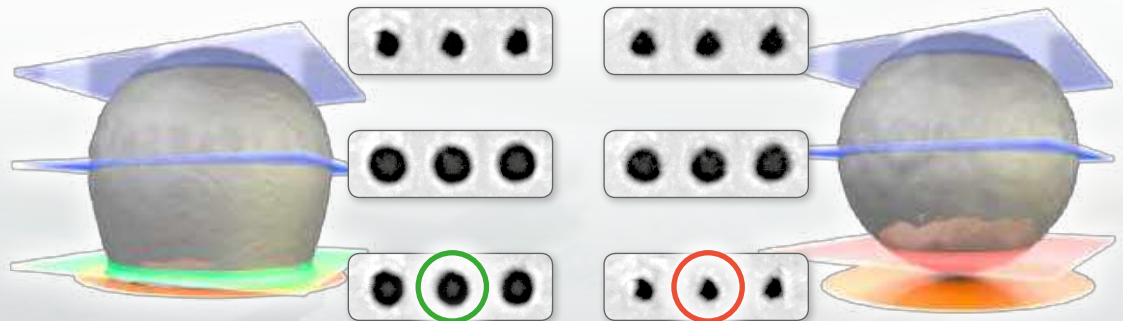
▶ Double-sided equipped assemblies – future-proof technology!

- ... provide more complex functionality by high density designs
- ... enable reduction of PCB dimensions
- ... are marked by increasing BGA utilisation



**Only 3D X-ray inspection
enables an efficient and
safe fault detection for
double-sided equipped
mounted PCBs!**

▶ Example for inspection of BGA solder joints with OptiCon X-Line 3D
... guarantees best production quality: analysis of each solder joint – within the production cycle!





AXI – 2.5D

AXI – 2D

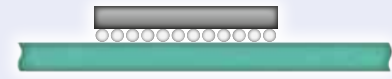
► X-Ray Inspection Application Opportunities



Visible solder joints and mounting position



Not visible solder joints



Solder joints for heat dissipation



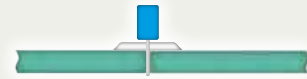
Single-sided SMD and THT mounting



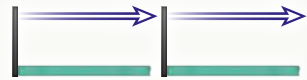
Double-sided mounting



Pin-in-paste



Line production



Test Task

Production Technology

with OptiCon X-Line 3D



safe utilisation



limited utilisation



unsafe utilisation



no utilisation

Automated Inspection (AOI/AXI)

AXI for Double-Sided Equipped PCBs

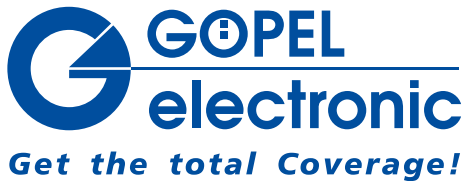


OptiCon X-Line 3D



OptiCon X-Line 3D

- Inline X-ray inspection system for highest quality demands
- Complete 3D reconstruction of maximum fault detection and ideal inspection of single layers
- Extraordinary inspection speed for inline utilisation
- Safe and comprehensive fault analysis at verification station through permanently available reconstruction



Get the total Coverage!

ISO 9001 certified

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