

# OptiCon X-Line 3D

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



# Automated X-Ray Inspection (AXI) 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 cm<sup>2</sup>/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

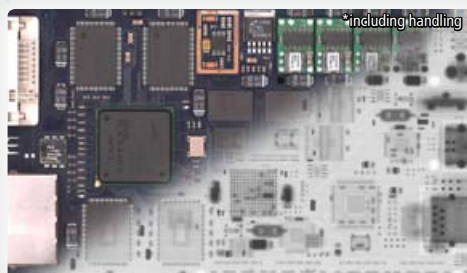
The intelligent combination of automatic X-ray (AXI) and optical (AOI) inspection ensures a close to 100 percent visual test coverage.

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.

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



### Reliability

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



uncalibrated image

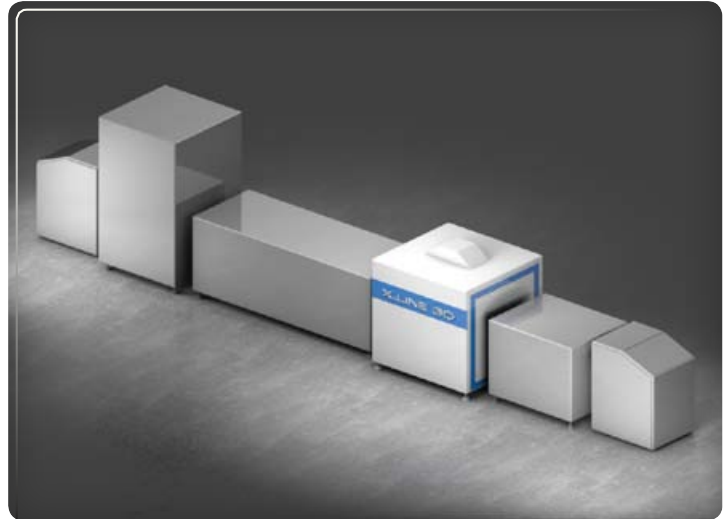


calibrated image

# Automated X-Ray Inspection (AXI) OptiCon X-Line 3D on the Shop Floor



Stand-alone (off-line operation)



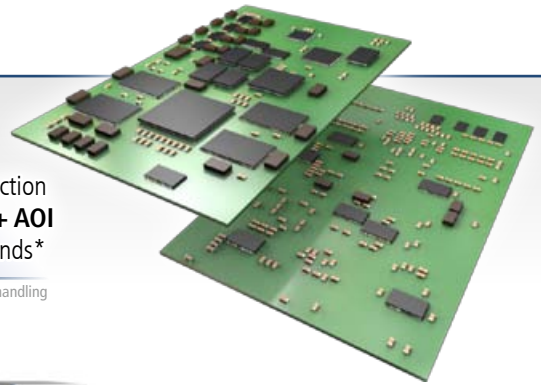
Integrated in the production line (in-line operation)

## 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: 11 µm  
 AOI fields of view: 8

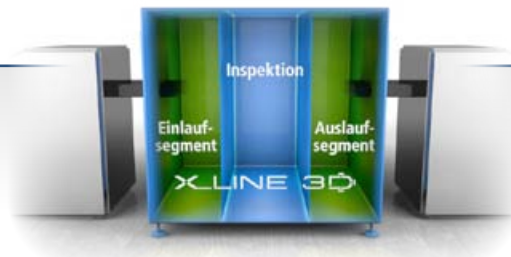
100 % inspection through AXI + AOI in **41** seconds\*

\*including handling



## Board conveyor system

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

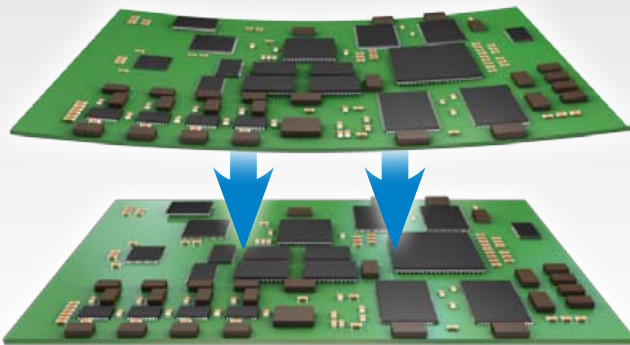


Handling time  
**4,8** seconds



## Correction of board warpage & stability monitoring

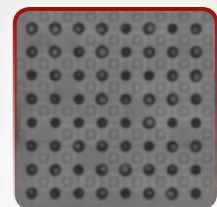
**Automatic correction** of board warpage allows for **precise reconstruction** of the board in **Z-axis** direction



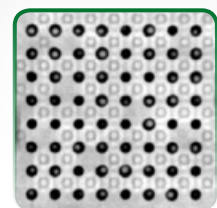
Correction per **laser height measuring system** and **image stack** respectively

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 (AXI)

## 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

extraordinary 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 assembly 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 assemblies 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 assemblies 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 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

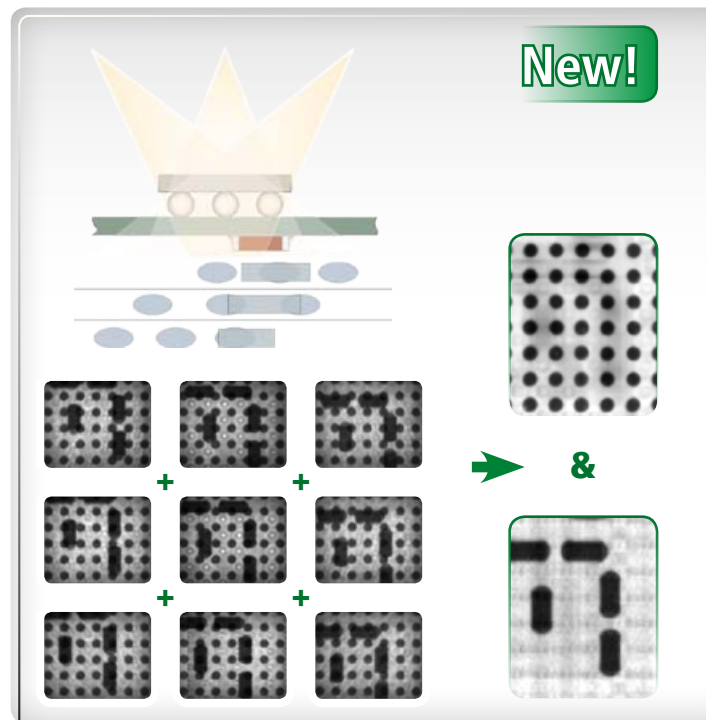
### 2D X-ray Inspection

#### Principle of Image Acquisition

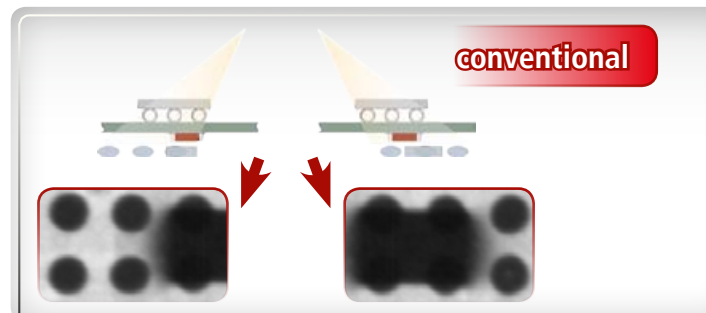
Assemblies are radiated through orthogonally.

#### Disadvantages

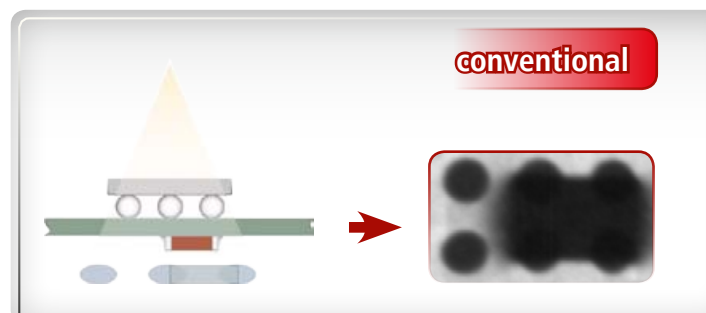
- superimposed solder joints (e.g. top and bottom side of the assembly) can't be inspected
- insufficient information about the quality of BGA solder joints
- no spatial assignment of detected faults



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

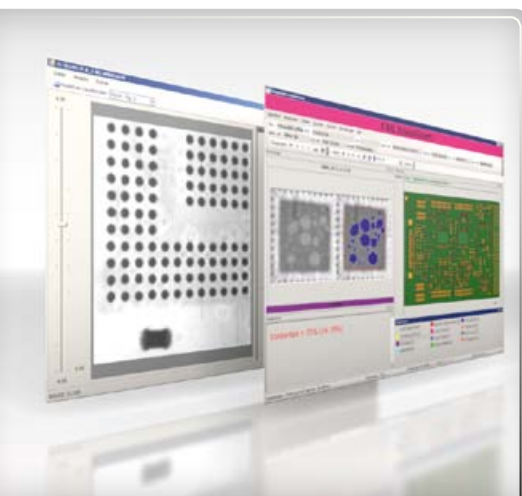


Superimposed solder joints orthogonally radiated through using 2D X-ray inspection

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



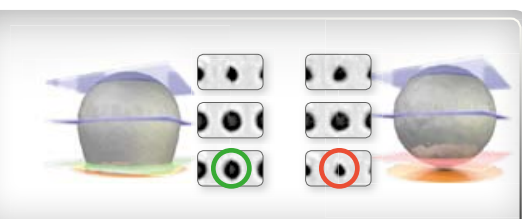
OptiCon XI-PILOT programme interface



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.

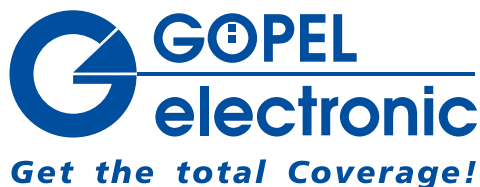
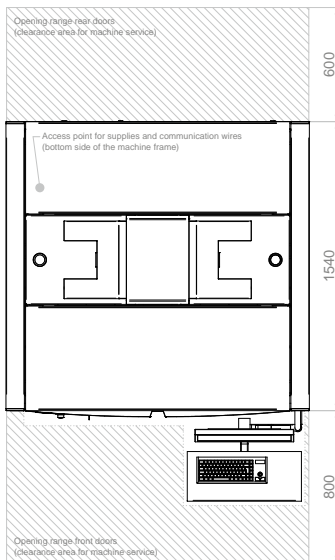
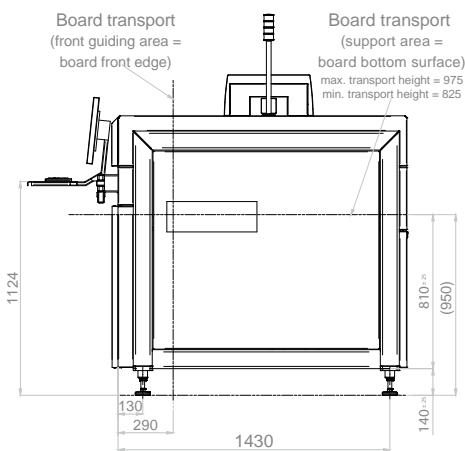
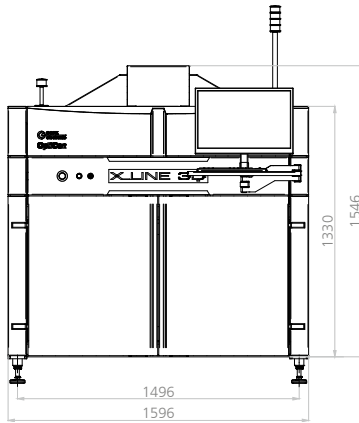
## Reliable Failure Analysis through Vivid Visualisation

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.

# Automated X-Ray Inspection (AXI) Technical Data



ISO 9001 certified

AXI-65/E/2012-10

Models	
Versions	OptiCon X-Line 3D X10
	OptiCon X-Line 3D X40

X-Ray Technology	
Tube type	maintenance-free, sealed microfocus X-ray tube
Tube voltage	max. 130 kV
Tube	max. 300 µA
Tube power	max. 39 W
Detector type	multi angle detector real-time image acquisition from different viewing angles
Grey scale resolution	12 bit
Resolution	variable: 6.3 µm – 30 µm typical: 10 µm, 15 µm, 20 µm, 25 µm; adaptable to inspection task
3D inspection method	digital tomosynthesis
3D inspection speed	OptiCon X-Line 3D X10: up to 10 cm <sup>2</sup> /s OptiCon X-Line 3D X40: up to 40 cm <sup>2</sup> /s
Calibration	geometric and grey scale calibration, automatic stability monitoring <sup>1</sup>
Z-axis adjustment	adaptable geometric magnification by means of motorised height positioning of the tube
X-ray protection	according to German Röntgenverordnung (RÖV), three segments, shielded, zero emission

Optical Image Acquisition Technology	
Resolution	10.5 µm
Field of view	42 mm x 42 mm
Lens	telecentric (pixel adapted lens)
Lighting	multi-spectral lighting, selectable from blue to IR

Board Handling	
Transport height	850 mm – 950 mm ± 25 mm
Width adjustment	automatic
Board size	max. 450 mm (L) x 400 mm (W) <sup>2</sup> / min. 50 mm (L) x 50 mm (W)
Board thickness	0.5 mm – 5 mm
Board support width	≥ 3 mm
Board weight	≤ 5 kg
Board warpage	automatic compensation
Component clearance	top side: 40 mm / bottom side: 65 mm
Handling time	approx. 4,8 s (concurrent loading/unloading and inspection)

System	
Line interface	SMEMA, Siemens
System supply	400 V, 5 kVA, 6 compressed air, < 20 NI/min
Typ. power consumption	< 700 W (average)
Dimensions	1596 mm (W) x 1540 mm (D) x 1470 mm (H, basis device) / 1720 mm (H, device including tube tower)
Weight	approx. 2.5 t

<sup>1</sup>up to board size max. 450 mm (L) x 280 mm (W) / <sup>2</sup>basic AOI module: 320 mm (L) x 400 mm (W); extended AOI module: 450 mm (L) x 400 mm (W)

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