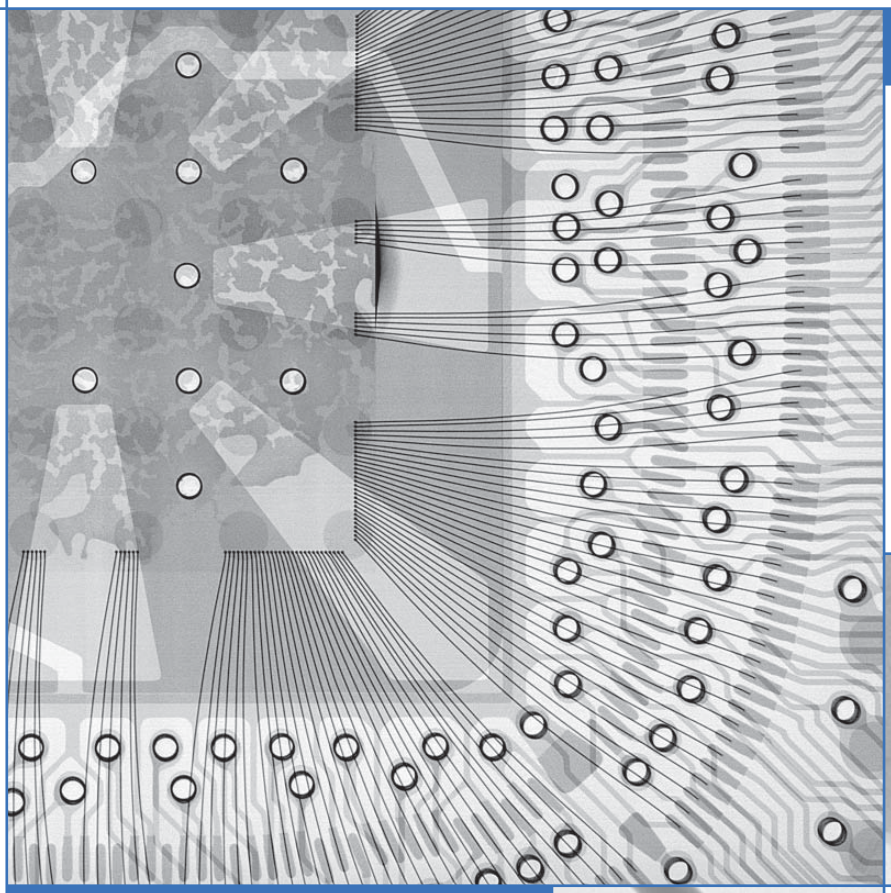
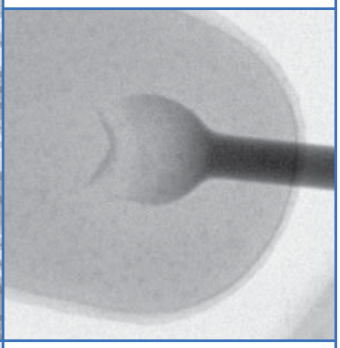
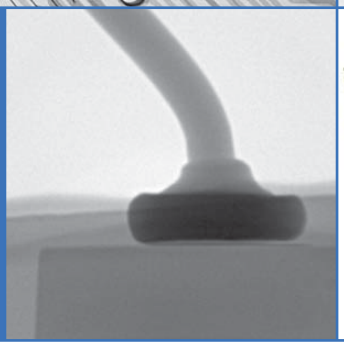
GE
Sensing & Inspection Technologies

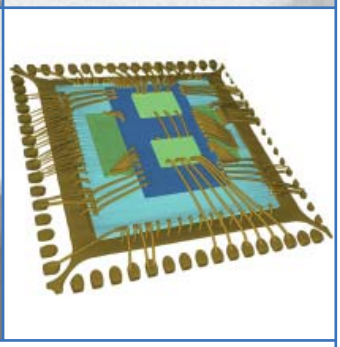


A GUIDE TO



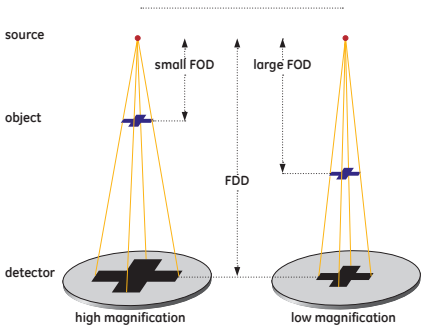
THE INSPECTION AND ANALYSIS OF ELECTRONIC PACKAGES





with phoenix|x-ray microfocus and nanofocus X-ray systems

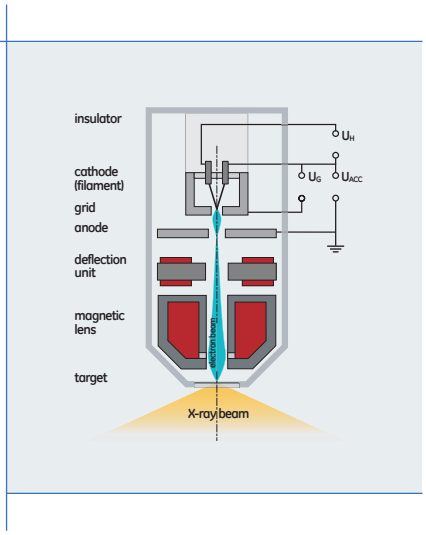
FAQs about X-ray



How X-ray inspection

works

X-ray starts with a sample being irradiated by an X-ray source and projected onto a detector. The geometric magnification M of the image is the ratio of focus-detector distance (FDD), Focus-object distance (FOD): M=FDD/FOD. The smaller the focal spot, the greater the resolution. With the nanofocus technology a unique detail detectability down to 0.2 microns can be achieved. phoenix|x-ray systems reach geometric magnifications over 2 000 x resulting in total magnifications beyond 24 000 x.



How X-ray tubes

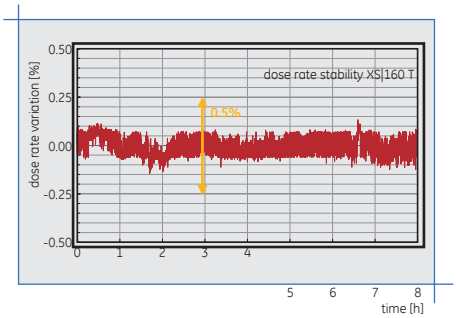
work

The heart of the X-ray machine is an electrode pair consisting of a cathode, the filament, and an anode, that is located inside a vacuum tube. Current is passed through the filament heating it up, causing the filament to emit electrons. The positively charged anode draws the electrons across the tube. Unlike with conventional X-ray tubes, the electrons pass through the anode into a specifically designed set-up of electromagnetic lenses, where they are bundled and directed onto a small spot on the target, a flat metal disc covered by a layer of tungsten. When the electrons collide with the target, they interact with the ions in the tungsten, causing X-rays to be emitted. Key to sharp, crisp X-ray images at micron or even submicron resolutions is the size of the focal spot, meaning the ability to focus the electron beam in such way that the area on the target where the electrons hit be as small as possible – an obstacle yet to be overcome by conventional X-ray machines.
However, phoenix|x-ray has mastered this challenge with its unique nanofocus tube providing detail detectabilities as low as 200 nanometers (0.2 microns).

What makes an excellent

X-ray?

In addition to resolution, maximum voltage, and power, stability is very important for reliable results and highest up-time. One of phoenix|x-ray's key techno-logy competencies are tube design and manufacturing.

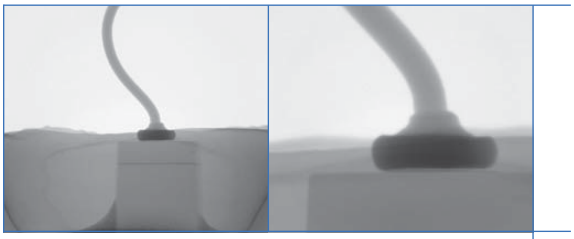


- High power nanofocus X-ray tubes up to 180 kV and unipolar microfocus X-ray tubes up to 300 kV maximum voltage
- Up to 200 nm (0.2 microns) detail detectability
- Dose-rate stabilization: the emitted intensity only varies by less than 0.5 % within 8 hours (see diagram)
- Anti-arcing: dedicated surface treatment during fabrication and automated warm-up procedures prevent discharges
- Self adjustment: all tube adjustments are performed automatically during warm-up to achieve optimum results
- Plug-in cathodes: pre-adjusted spare cathodes prevent malfunction due to wrong filament adjustment and minimize down-time to less than 20 min.
- Target check: target condition is checked automatically; automatic target wear is indicated

Why can the collision

protection be deactivated?

phoenix|x-ray systems come standard with a password-protected, anti-collision feature to ensure the protection of your samples. When inspecting certain samples, it might become necessary to deactivate the collision protection (e.g. with 25 µm bond wires, which, even for magnifications of just 500 x, need to be as close as 4 mm to the tube head). phoenix|x-ray provides the user the flexibility when dealing with small samples. Unlike with conventional systems, the X-ray tube is located above the sample tray allowing the user to move the sample as close to the tube head as needed.



FOD = ~4 mm: 500 x Sample touching the tube: Maximum magnification

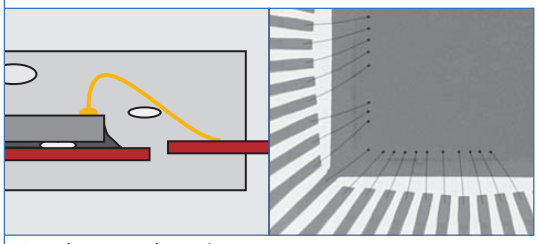
The View Inside

What can X-ray inspection tell us about package quality?

Electronic packages are sophisticated electronic devices with complex, internal features. In order to meet the quality requirements of the industry, X-ray inspection solutions must be capable of delivering detail detectabilities in the submicron range and detecting hidden defect flaws.

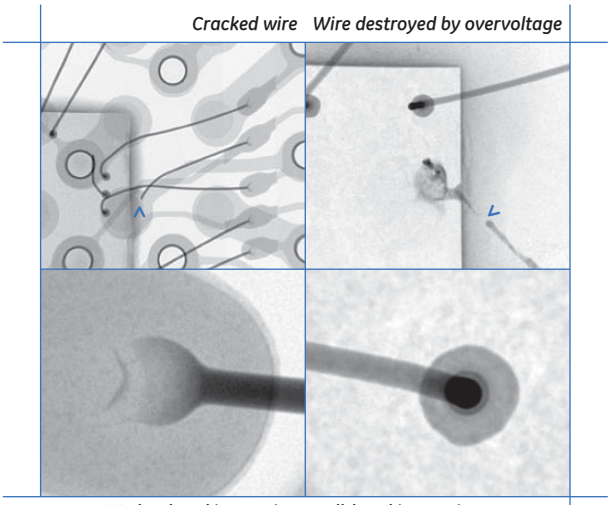
phoenix|x-ray offers automated microfocus and nanofocus X-ray inspection solutions for any package inspection task including, but not limited to the following:

Standard IC packages: DIP, SOT, VSOP, (P)LCC, QFP, Flat Pack



IC-package, top-down view

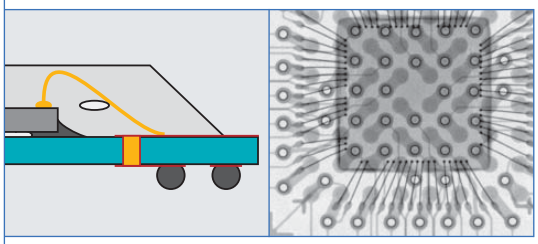
Any internal details such as bond wires, inner and outer bonds, die, die attach, lead frame and moulding can be examined for defects (e.g. broken wires, excessive wire sweep, extraneous or crossing wires, die attach voids and die tilt, die cracks, defective lid seals, moulding voids, entrapped particles and delaminations).



Cracked wire *Wire destroyed by overvoltage*

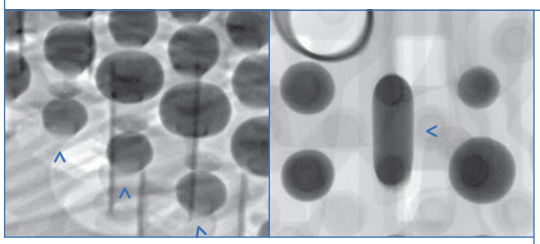
Wedge-bond inspection *Ball-bond inspection*

Wire-bonded area array packages: PBGA, CSP, etc.



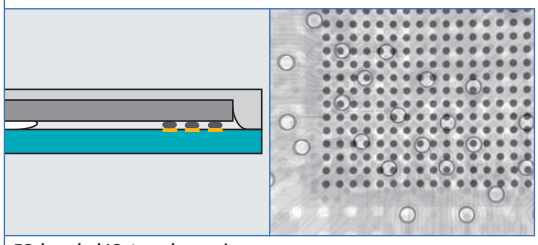
Chip-scale package in top-down view (not balled yet)

The image gives a clear view of the integrity of the vias and lead tracks of the PCB and the quality of the solder joints.



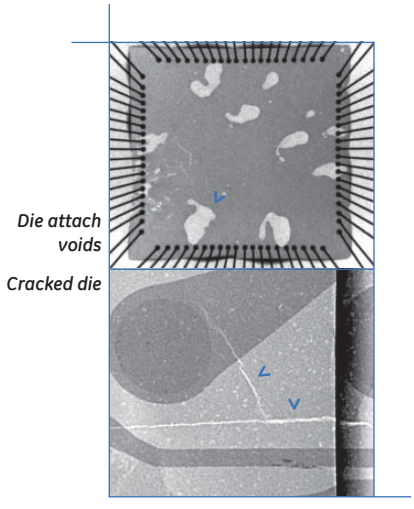
Shape deviations and opens in flip-chip bonds *Bridge between flip-chip bonds*

Flip-chip bonded area array packages: CBGA etc.



FC-bonded IC, top-down view

Applications include the inspection of microscopic solder joints connecting IC and ceramic substrate as well as underfill inspection. The most common defects are open solder joints, missing solder joints, solder bridges, solder and underfill voids.



Die attach voids

Cracked die

Image definition and contrast

What is it that makes the difference?

Image definition and contrast are both key to detecting. With the nanofocus technology with detail detectabilities down to 200 nanometers, submicron resolutions and a fully digital high-contrast|detector that outperforms any image intensifier-based image chain, phoenix|x-ray is once more leading the way in X-ray inspection technology.

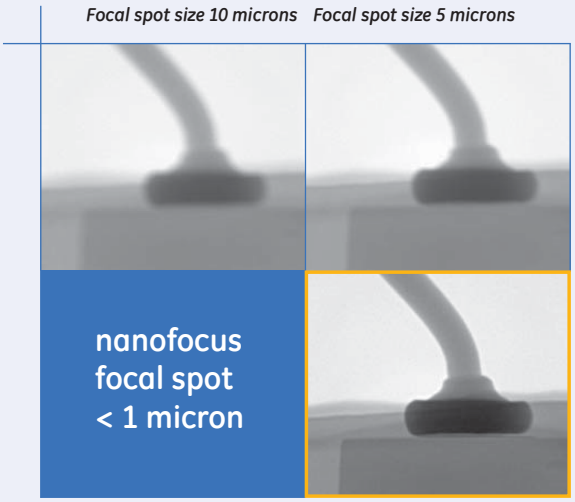
High dynamic digital detectors

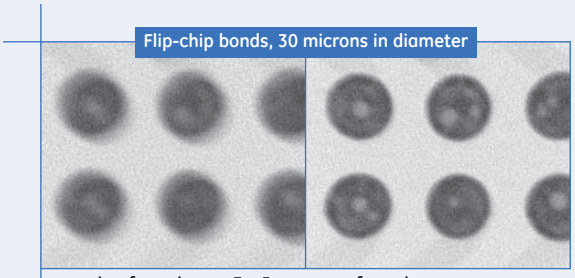
active temperature stabilization

The image quality is essential for an optimal defect coverage of all 2D and 3D inspection tasks. The new active temperature stabilized GE DXR detectors ensure a very low noise live-imaging. Due to its high dynamic, the DXR detector shows a brilliant live image with 30 frames per second at full resolution.

Unrivaled resolutions

nanofocus technology

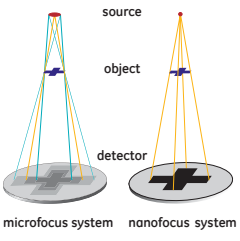




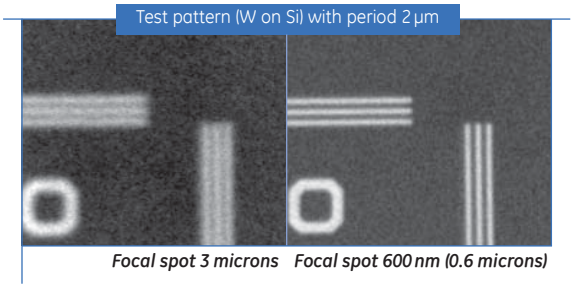
microfocus image F = 5 µm *nanofocus image*

Technology

What is the difference between nanofocus and microfocus tubes?



Microfocus X-ray tubes have focal spots that are as small as 3 microns in size. But penumbra effects, and, as a consequence, residual unsharpness, still occur. With its nanofocus technology with focal spot sizes well below 1 micron, phoenix|x-ray has successfully managed to eliminate the penumbra effect even when using highest-intensity X-rays.

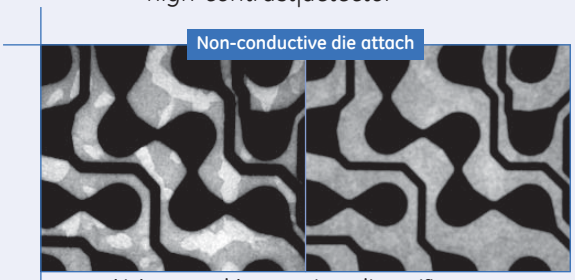


Focal spot 3 microns *Focal spot 600 nm (0.6 microns)*

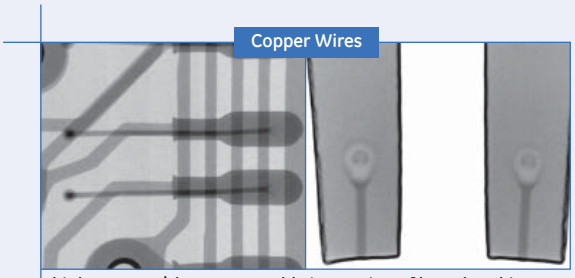
Verification of resolution using a periodic test pattern. If the grid period is the same size as the focal spot, the pattern vanishes. Using nanofocus technology, the bars are clearly visible proving that nanofocus tubes deliver detail detectabilities well below 1 micron – **proved with Jima.**

Superior contrast

high-contrast|detector



high-contrast|detector *image|intensifier*

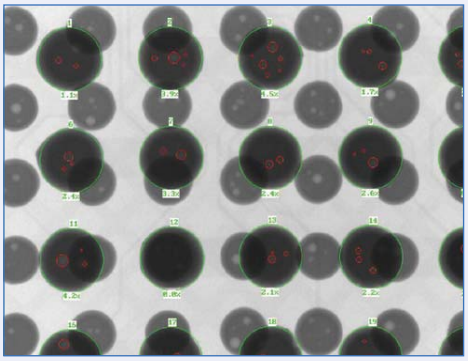


high-contrast|detectors enable inspection of low absorbing features

Automated Inspection

The efficient way of process control and rework: AXI

Efficient soldering process control requires the acquisition of statistical data on the solder joints of a larger number of samples. phoenix|x-ray offers a range of plug-in software modules for the automatic evaluation of standard solder joints like BGA, QFP, QFN, or PTH. For non-typical interconnections, appropriate modules can quickly be customized with the XE² (X-ray image Evaluation Environment) software. Together with the high precision CNC manipulation, which comes standard with phoenix|x-ray systems these modules enable the automatic X-ray inspection (AXI) of solder joints at minimum set-up time, due to teach-in programming and auto-setup routines. An additional software package – quality|review – is the perfect connection to rework. phoenix|x-ray's inspection modules can also easily be activated during manual inspection as a quick inspection aid.



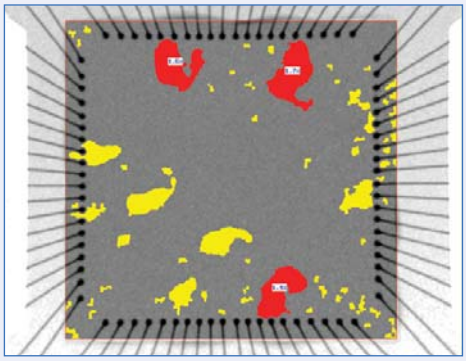
c4|module

flip-chip inspection

Software for the automated X-ray analysis of microscopic solder joints, even with background structures present. The analysis runs fully automated and is extremely time-saving.

The following c4-parameters can be inspected:

- Missing solder balls
- Void size
- Void percentage
- Number of voids

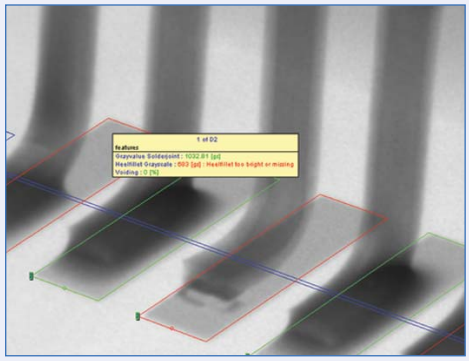


vc|module

voiding calculations

Software designed for the automated voiding analysis of die-attach and planar solder joints with versatile set-up options:

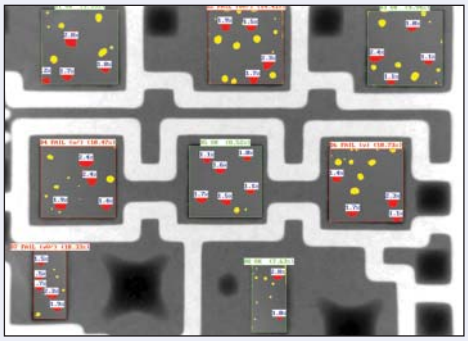
- Calculation of the total voiding percentage
- Calculation of the void count
- Sorting voids according to variable thresholds
- Definition of hot zones
- Calculation of the minimum void diameter
- Calculation of die tilt and rotation
- Automated die inspection
- Dimple solder joint correction
- Inspection and analysis of multiple-die packages



x|act

AXI with highest defect coverage

As a solution for AXI with highest defect coverage, phoenix|x-ray provides calibrated high precision offline AXI systems including the unique x|act software package for fast and easy offline CAD-programming. Small views with highest resolution of a few micrometers, 360° rotation and oblique viewing up to 70° ensure to meet highest quality standards. Among the automated X-ray inspection, the AXI system can be used for manual failure analysis or 3D computed tomography as well.



Multiple-die attach evaluation

Technology

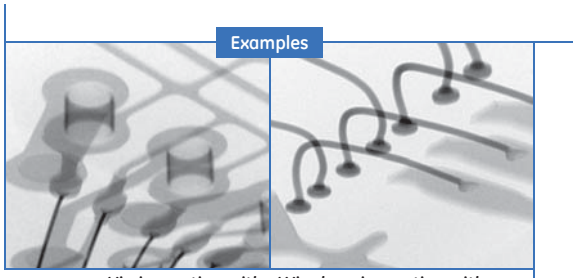
The radiation dose typically used in X-ray inspection is only a thousandth of the dose rate that would cause damage to semiconductor components. phoenix|x-ray provides a variety of options for controlling and adjusting the dose rate e.g.:

- low-dose|mode
- automated inspection routines (AXI)
- collimated beams
- self-filtering target

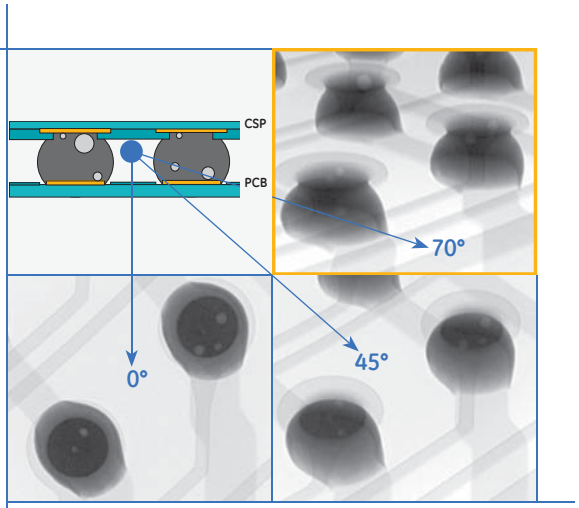
The Third Dimension

Oblique or straight X-ray inspection seen from a different perspective

Sometimes when inspecting a sample, it may become necessary to see your sample from a different angle. An example of this would be an inspection via platings or wire loops. phoenix|x-ray systems provide oblique views of up to 70 degrees using the unique ovhm-technology. Automatic isocentric manipulator movement locks the field of view during rotation and ovhm tilt in the image centre.

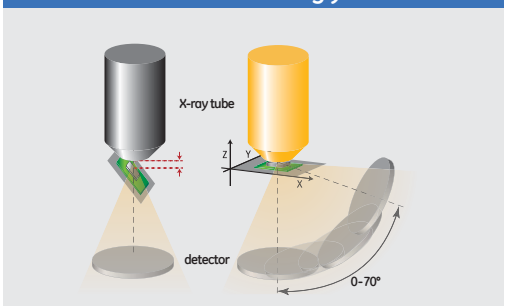


Via inspection with ovhm *Wire loop inspection with ovhm*



ovhm: oblique views are an excellent means for gaining a maximum of information about the internal features of a sample. At a tilt angle of 70 degrees, the profile of CSP-solder joints including voids are clearly visible. Unlike with a tilting angle of 45 degrees, component and board parts can be clearly distinguished.

Technology



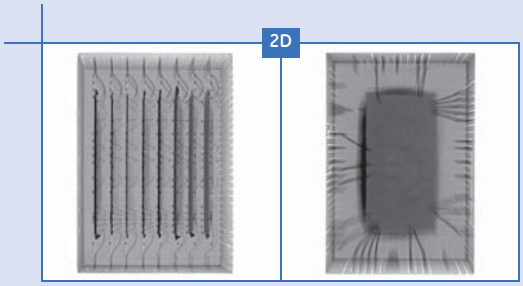
ovhm: Oblique views at highest magnifications

Conventional tilt techniques generate oblique views by simply tilting the sample to the side, which involves moving one part of the sample further away from the X-ray tube resulting in a decrease in magnification. The ovhm|module was specifically designed to enable oblique views of up to 70 degrees and 0 to 360 degree rotations without a decrease in magnification. Magnification remains the same because the distance between focus and sample does not change while the detector is being tilted.

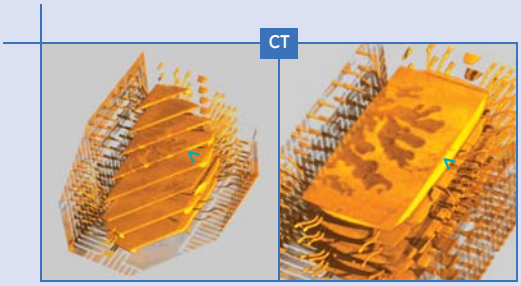
High-resolution 3D imaging

nanoCT®

The proven and successful v|tome|x technology by phoenix|x-ray is also available as an add-on for the nanome|x system. High-power nanofocus X-ray technology paired with a fast reconstruction software deliver unrivaled, highest-quality inspection results with nanoCT® image resolutions. This technology is especially suitable for the inspection and three-dimensional analysis of smaller samples.



2D images of a memory cube with stacked dies, frontal and side view. Deeper-lying features are concealed, making a thorough analysis impossible.



3D nanoCT®-image: Each individual die attach is clearly visible and can be examined for voids.

Systems

phoenix|x-ray offers a wide range of X-ray systems in different configurations for a variety of inspection tasks in the electronics and semiconductor industries. phoenix|x-ray's systems have superior specifications that are able to solve the highest demands:

nanome|x

the ultimate X-ray solution

This automated X-ray system with superior specifications satisfies the highest demands: The 180 kV / 15 W high-power nanofocus tube (4-in-1) covers the full range from submicron resolution to high intensity applications. Due to the easy view configuration, the X-ray image displays the sample exactly as the operator sees it through the radiation protection window. The digital realtime image chain with 4 MPixel camera provides an excellent contrast resolution and enables oblique views up to 70 degrees at magnifications well above 24 000 x. For samples of poor contrast the system may be equipped with a high dynamic fully digital high-contrast|detector – as supplement to the image chain, offering unique performance and versatility. Optionally, the nanome|x may be equipped with nanoCT® capability.

microme|x

automated solder joint inspection

The microme|x is a high-resolution automated X-ray inspection (AXI) system that is most suitable for failure analysis in the semiconductor and electronics industry. It comes standard with an ultra high performance 180 kV / 20 W X-ray tube for sub-micron feature recognition > 0.5 µm and a high-resolution 2 MPixel digital image chain. This system provides a total magnification of up to 23.320x (without software zoom) and oblique angle views of up to 70 degrees. The microme|x combines proven high-resolution 2D and 3D CT X-ray technology in one system. With the new x|act package for CAD based AXI programming the microme|x is the system of choice to ensure meeting zero defect requirements.

pcb|inspector

high performance - low maintenance

pcb|inspector is the solution for process control on standard BGA / SMD and planar solder joints. Due to the maintenance-free closed tube and the high quality image chain the pcba|inspector provides excellent defect recognition at medium magnifications. Optional manipulation upgrades enable oblique views.

nanotom®

highest resolution in three dimensions

The nanotom® comes standard with a 180 kV / 15 W ultra high-performance nanofocus tube and precision mechanics for maximum stability. With voxel resolution as low as 500 nanometer, the nanotom® is the inspection solution of choice for 3D CT applications in a wide range of fields. With its small footprint, the nanotom is suitable for even the smallest labs.

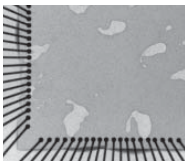
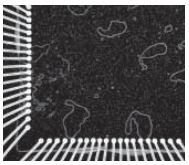
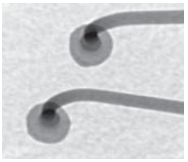
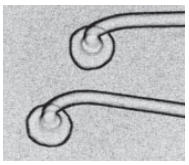
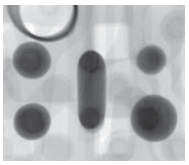
For many applications, the nanotom® offers a viable alternative to synchrotron-based computed tomography.

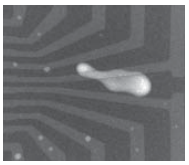
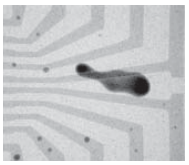
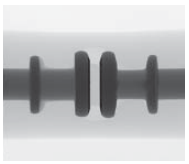
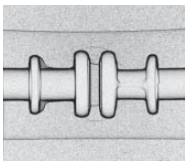
Technology

Closed tube or open tube?

Closed tubes: All tube components are contained in a sealed vacuum vessel container. Closed tubes are maintenance-free and are completely replaced at the end of their lifetime.

Open tubes: All components and wear-out parts are accessible and replaceable, the tube is continuously evacuated by a turbomolecular pump. Open tubes yield higher resolution and magnification and are not limited in lifetime.

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