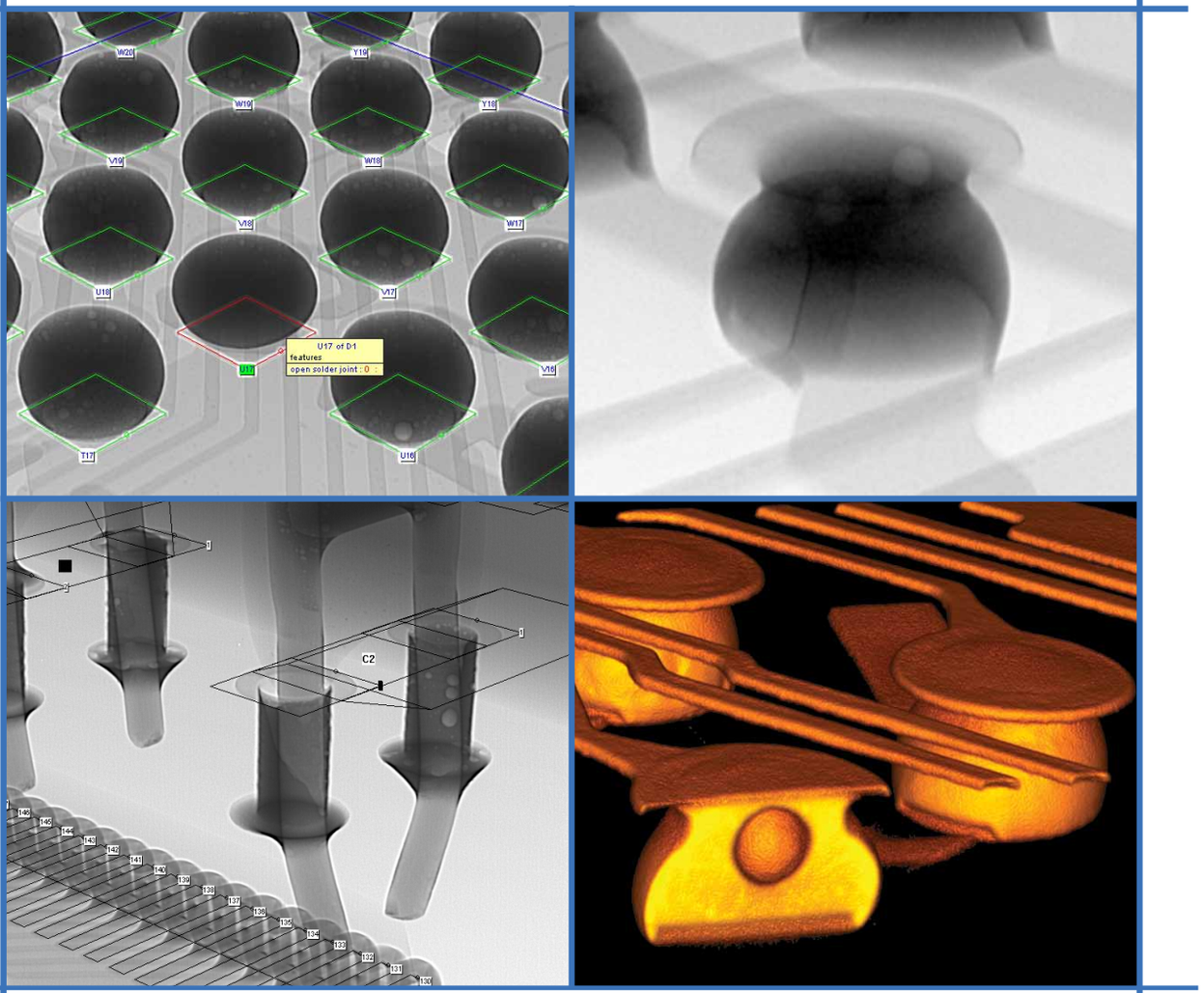
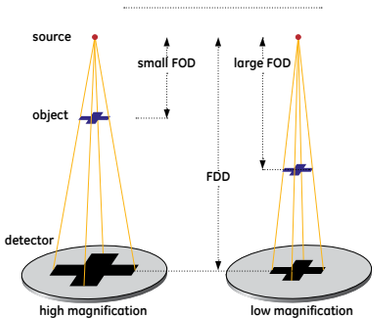
GE
Inspection Technologies

SOLDER JOINT INSPECTION AND ANALYSIS



with GE's phoenix|x-ray microfocus and nanofocus X-ray systems

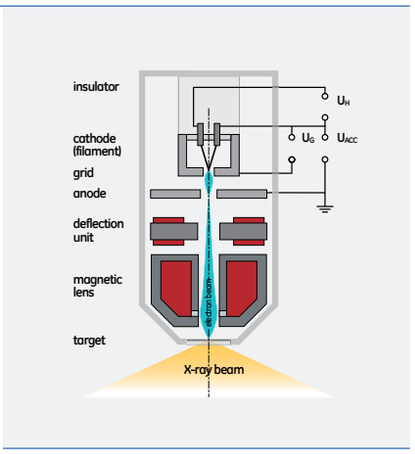
FAQs about X-ray



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 an unique detail detectability down to 0.2 microns can be achieved. phoenix|x-ray systems reach geometric magnifications over 2,000x resulting in total magnifications beyond 24,000x.



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?

One of phoenix|x-ray's key technology competencies are tube and generator design and manufacturing ensuring reliable results and highest up-time.

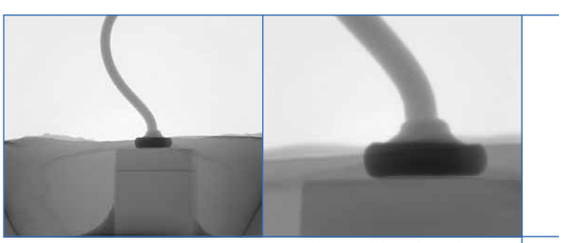
GE's unique 180 kV high power nanofocus X-ray tube

- High power nanofocus X-ray tubes up to 180 kV and unipolar microfocus X-ray tubes up to 300 kV maximum voltage.
- Down to 200 nm (0.2 microns) detail detectability.
- 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.
- long-life|filament: ensuring high emission current CT with up to 10 times increased filament lifetime of directional target tubes.
- diamond|window: high output of up to max. 20 W power with high-resolution.
- Target check: target condition is checked automatically; automatic target wear is indicated.

Why can the collision

protection be deactivated?

For ultimate protection of your sample, all phoenix|x-ray systems come standard with a password-protected anti-collision feature. But when inspecting certain samples, it might become necessary to deactivate the collision protection, as for example with 25 µm bond wires, which, even for magnifications of just 500x, need to be as close as 4 mm to the tube head. phoenix|x-ray has come up with a solution to give the user maximum flexibility when dealing with very 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.



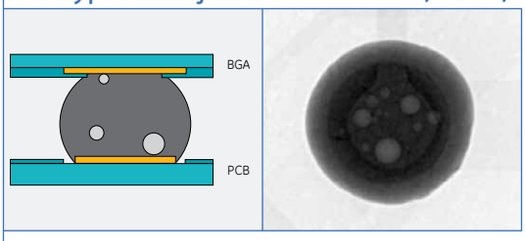
FOD-=-4 mm: 500x ***Sample touching the tube: Maximum magnification***

The View Inside

Why to inspect solder joints with X-ray?

The reliability of electronic assemblies strongly depends on solder joint quality. Acceptability criteria are mainly based on shape and dimension of the solder joints. As quality demands and technology for assembly process for new package types increase, many solder joints are no longer directly visible. Fortunately, they can easily be inspected by advanced microfocus and nanofocus X-ray systems. phoenix|x-ray offers dedicated analysis and automatic inspection solutions for any type of solder joint:

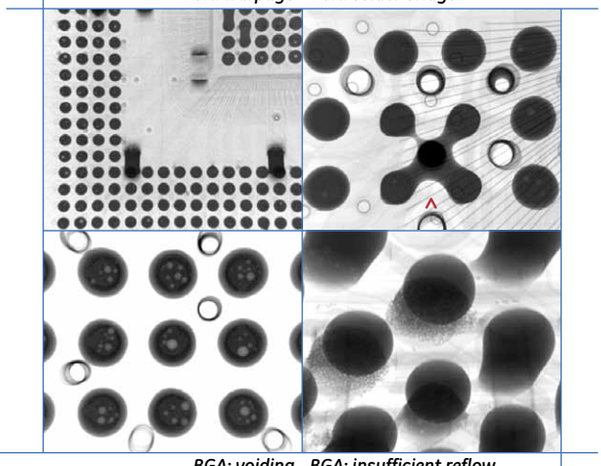
BGA type solder joints such as PBGA, CBGA, CGA, etc.



Scheme of a BGA solder joint , X-ray image of a BGA solder joint (top-down view)

All dimensions and features of the solder joint are imaged: diameter, thickness (grey value), lands and contact areas (darker and brighter circles), voids (bright spots). All defects that have any influence on the solder joint's shape are detectable:

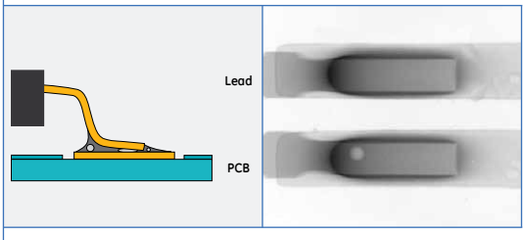
Bridges, opens, missing joints, warpage, popcorning, component tilt, voids, diameter deviations, roundness, shape deviations (roundness), fuzzy edges (insufficient reflow), misregistration.



BGA: warpage *BGA: solder bridge*

BGA: voiding *BGA: insufficient reflow*

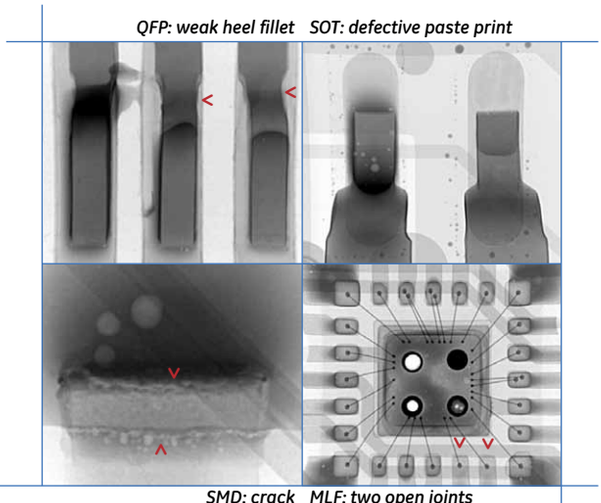
Gull Wing and flat ribbon solder joints such as QFP, SOT, PLCC, Chip devices etc.



Scheme of a Gull Wing (QFP) solder joint, X-ray image of a QFP solder joint (top-down view)

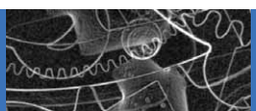
In addition to toe and side fillets the X-ray image reveals hidden features of the interconnection: the heel fillet which is most important for the reliability of the solder joint and voids.

Detectable defects: Bridges (in particular under the component), opens, defective paste print, insufficient co-planarity, incomplete fillets, de-wetting, insufficient reflow, mis-registration, cracks.



QFP: weak heel fillet *SOT: defective paste print*

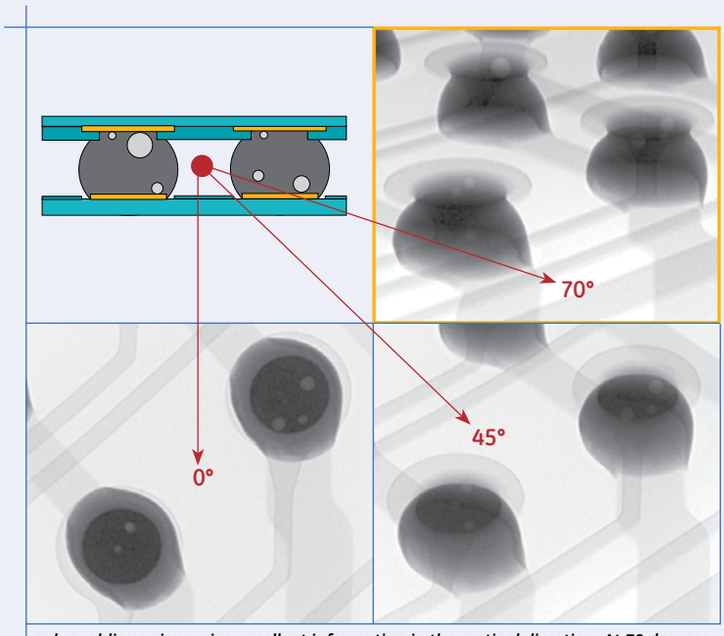
SMD: crack *MLF: two open joints*



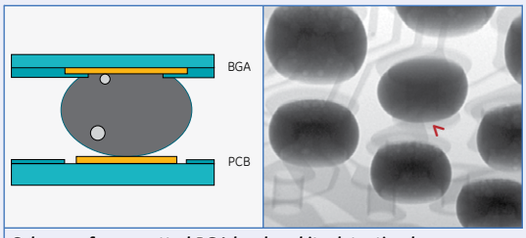
The Third Dimension

Just look from the side
ovhm - oblique views at highest magnification

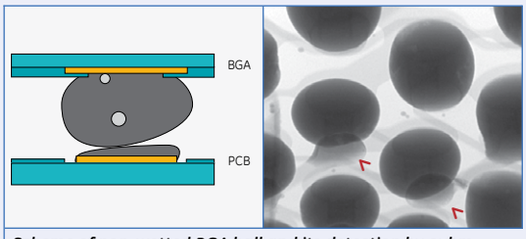
Some acceptability criteria refer to a side view and many defects can be seen best from the side, in other words, some information about the vertical dimension is required. phoenix|x-ray systems provide this information by oblique view – up to 70 degrees – at highest magnification. As an example, this enables the user to see open BGA solder joints directly instead of interpreting signatures.



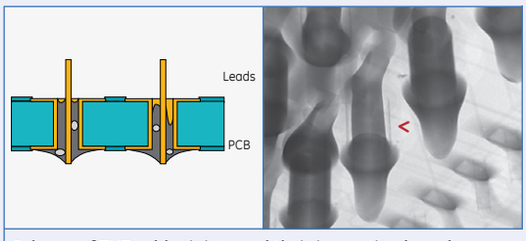
ovhm: oblique views give excellent information in the vertical direction. At 70 degrees the profile of these CSP solder joints is fully displayed and even the void position can be clearly determined. In contrast to 45 degrees, at 70 degrees the component and board pads are completely separated and can be inspected without any interference.



Scheme of non-wetted BGA land and its detection by ovhm: the land is empty

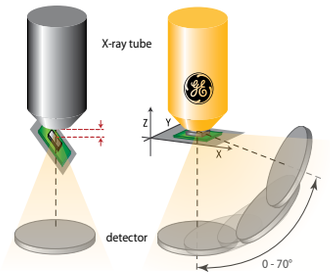


Scheme of non-wetted BGA ball and its detection by ovhm: paste solder and ball are separated



Scheme of THT solder joints and their inspection by ovhm: one through-hole is not filled and the hole plating is not wetted by the solder

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.

Automated Inspection

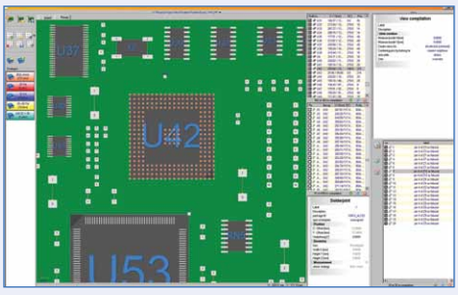
The efficient way of process control and rework

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 automated evaluation of standard solder joints like BGA, QFP, QFN, or PTH. For non-typical interconnections, appropriate modules can quickly be customised 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 automated 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.

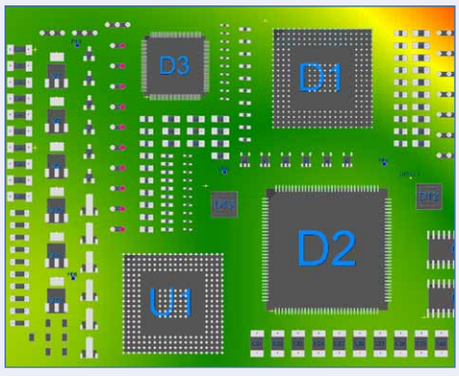
phoenix x|act µAXI

Fully automated CAD based high-resolution X-ray inspection for extremely high defect coverage

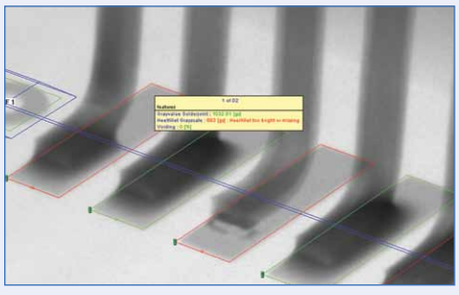
As a solution for µAXI with high magnification and repeatability, GE provides calibrated high precision offline µAXI systems including the unique phoenix x|act software package for fast and easy offline CAD programming. Small views with a resolution of up to a few micrometers, 360° rotation and oblique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



Fast and easy programming: just assign the inspection strategies and let x|act generate the automated inspection program



Visualization of board distortion



Live CAD overlay in ovhm with inspection results

Efficient CAD programming

minimized setup time

- Import of CAD-data
- Easy pad-based offline programming
- Optimized inspection strategies for different pad types
- Fully automated generation of inspection program even in oblique view and multiple angular positions per component
- Full program portability for all compatible phoenix|x-ray inspection systems with x|act

3D auto-referencing

optimized positioning accuracy

Automated measurement and compensation of height differences and distortions:

- phoenix|x-ray inspection systems equipped with x|act operator or pro come standard with high precision CNC manipulation
- Local 3D height and distortion referencing by X-ray
- Highest precision through use of multiple fiducials
- Automated correction of image chain distortion
- Extremely high positioning accuracy even at oblique viewing and rotation

Live 3D CAD overlay

highest magnification in oblique view

- Perfect orientation through live overlay of CAD-data and test results even in rotated oblieque views
- Pad ID available at any time
- Inspection results and images include correct pad numbering for easy rework
- Easy pad identification even in manual inspection

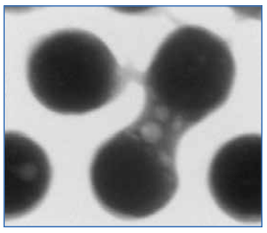
Inline or offline inspection?

With common inline AXI, the inspection depth is normally determined by the throughput of the SMT line. Principally, X-ray inspection takes much more time than AOI. The higher the defect coverage, the more inspection time is required. For zero defect production inspection with small fields of view with micrometer resolution, 360° rotation and oblique viewing up to 70° is essential. To ensure these higher defect coverage requirements, µAXI has to be performed beside the production line.

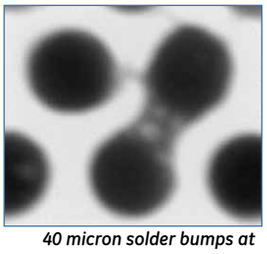
Anticipating the Future

Inspecting the smallest and finest

nanofocus and digital imaging



40 micron solder bumps at nanofocus resolution



40 micron solder bumps at microfocus resolution

Miniaturization and new assembly techniques demand resolution in the submicron range and also highest contrast resolution. With the nanofocus tube technology together with digital image chains or fully digital detector arrays, phoenix|x-ray provides proven detail detectability down to 200 nm (0.2 microns) combined with superior contrast resolution. In this way fine details and slight variations in thickness, such as those caused by tiny voids in microscopic Flip Chip solder joints are detected.

High dynamic digital detectors

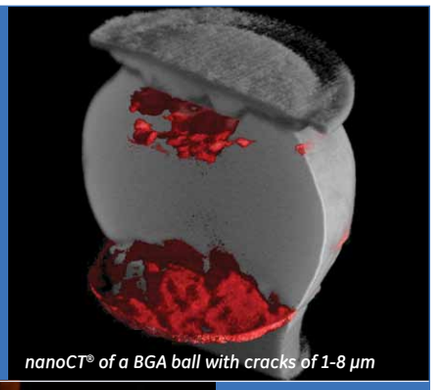
Active temperature stabilization

The image quality is essential for an optimal defect coverage of all 2D and 3D inspection tasks. Due to its high dynamic, the new active temperature stabilized GE DXR digital detector arrays ensure a very low noise fast and detailed live inspection with up to 30 frames per second at full resolution. This makes it possible to run a 3D CT scan within only 10 seconds.

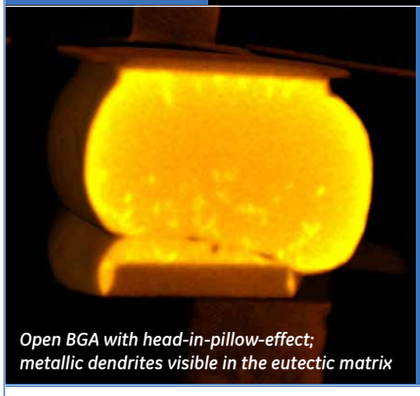
High-resolution 3D-imaging

nanoCT®

The combination of phoenix|x-ray's high-power nanofocus X-ray tube and optimized reconstruction software enables unprecedented nanoCT® image resolution and quality. This technology allows the inspection and 3-dimensional visualization of the internal details of smaller specimens with submicrometer voxel resolution.



nanoCT® of a BGA ball with cracks of 1-8 µm



Open BGA with head-in-pillow-effect; metallic dendrites visible in the eutectic matrix

Technology

phoenix|x-ray systems help you meet the standards

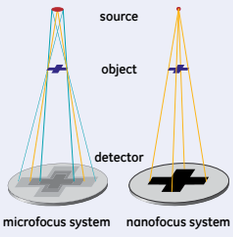
The phoenix|x-ray solder joint inspection software modules include all X-ray accessible criteria mentioned in the commonly applied standards for acceptability of PCB assemblies, namely:

- IPC-A-610 Revision E
- IPC 7095

The modules are continuously updated to adapt them to revisions of the standards.

Technology

What is the difference between nanofocus and microfocus tubes?



Although the focal spot of microfocus tubes is as small as 3 microns, it is still large enough to cause a half shadow, known as the penumbra effect. This results in a residual unsharpness and can be avoided by using nanofocus technology. Nanofocus provides focal spots well below one micron while maintaining the highest intensity needed.

Systems

GE's phoenix|x-ray business offers a wide range of systems and system configurations dedicated to various 2D and 3D inspection tasks in printed circuit board assembly:

phoenix nanome|x

the ultimate nanofocus X-ray solution

This automated X-ray system with superior specifications satisfies even 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 and magnifications well above 24,000 x. For samples of poor contrast the system may be equipped with a high dynamic fully digital DXR detector array – as supplement to the image chain, offering unique performance and versatility as well as live imaging with up to 30 fps. Optionally, the nanome|x may be equipped with nanoCT® capability.

The tube makes the difference: phoenix nanome|x / microme|x

phoenix nanotom s and m

outstanding spatial and contrast resolution on a wide sample range

Both versions of the nanotom come standard with a 180 kV / 15 W ultra high-performance nanofocus X-ray tube and precision mechanics for extremely high stability. With voxel resolution as low as < 500 (s) or even <300 (m) nanometer and below, the nanotom is the inspection solution of choice for 3D nanoCT® applications in a wide range of fields. Equipped with its unique high dynamic temperature stabilized 3,072 x 2,400 pixels GE DXR detector, the nanotom m scans samples up to 240 mm in diameter. With its small footprint, the nanotom is suitable for even the smallest labs. For many research applications, the nanotom offers even a viable alternative to synchrotron-based computed tomography.

phoenix microme|x

automated solder joint inspection

The phoenix microme|x is a high-resolution automated X-ray inspection (AXI) system that is suitable for failure analysis in the semiconductor and electronics industry. The microme|x combines proven high-resolution 2D and 3D X-ray technology in one system. This system 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. The microme|x provides a total optical magnification of up to 23,320 x and oblique angle views of up to 70 degrees. Optionally, it may be equipped with GE's DXR digital detector array for brilliant live imaging and the capability for high-resolution CT for advanced 3D failure analysis.

phoenix x|aminer

strong entry-level inspection system

With it's 160 kV / 20 W microfocus X-ray tube, GE's phoenix x|aminer meets the requirements for high-resolution X-ray inspection of electronic assemblies, components and PCBA. The phoenix x|act base software package offers ease of use allowing manual as well as automated solder joint inspection.

What does "easy and intuitive use" mean?

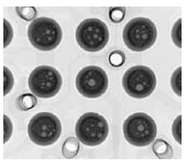
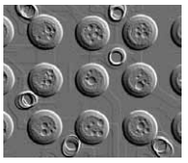
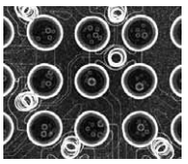
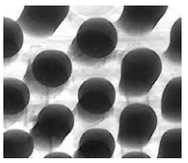
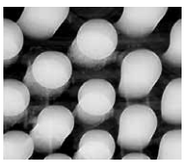
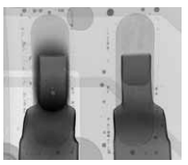
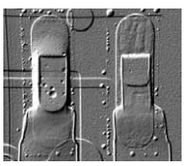
- Due to the "Easy View Configuration" the X-ray image shows the object exactly as the operator sees it through the radiation protection window
- Precise and easy operation by using the mouse, joystick or key board
- phoenix|x-ray systems can be operated in either sitting or standing position
- Programming is possible in different layers of complexity, each of them supported by an intuitive graphically oriented or CAD based user interface

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.

Regional Contact Information

Europe, Asia, Africa, South America
GE Sensing & Inspection Technologies
Niels-Bohr-Str. 7
31515 Wunstorf
P.O. Box 6241
31510 Wunstorf
Germany

Tel.: +49 5031 172 0
Fax: +49 5031 172 299
E-mail: phoenix-info@ge.com
phoenix-asia@ge.com

Americas
GE Inspection Technologies, LP
50 Industrial Park Rd
Lewistown, PA 17044
USA

Tel.: +1 (717) 242 0327
Fax: +1 (717) 717 242 2606
E-mail: phoenix-usa@ge.com

www.ge-mcs.com/phoenix

GEIT-31101EN (11/11)