Issue 01 / 2003

the x-ray times

dates

visit us at the following tradeshows:

21 - 24 January 2003
Componex/electronicIndia
Bangalore, India
Stand: Hall B, No. B53

26 - 28 February 2003
Aerospace Testing Expo
Hamburg,Germany
Stand: Hall 2, No. 2069

11 - 13 March 2003
Semicon China
Shanghai, China
Stand:Hall2, No. 2731

26 - 28 March 2003
ELKOM
Helsinki, Finland
Stand: c/o Cyncrona Oy

25 - 28 March 2003
Intertronic
Paris, France
Stand: 7/1, Allée C, No. 29

29 March - 03 April 2003
APEX
Anaheim/California, USA
Stand:

01 - 03 April 2003
Semicon Europa
Munich, Germany
Stand: t.b.d.

08 - 10 April 2003
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08 - 11 April 2003
Nepcon Shanghai
Shanghai, China
Stand: German Pavillon

For more information
please refer to our website:
www.phoenix-xray.com →news

World premiere: Compact X-ray system with „Plug-and-play“-modules launched

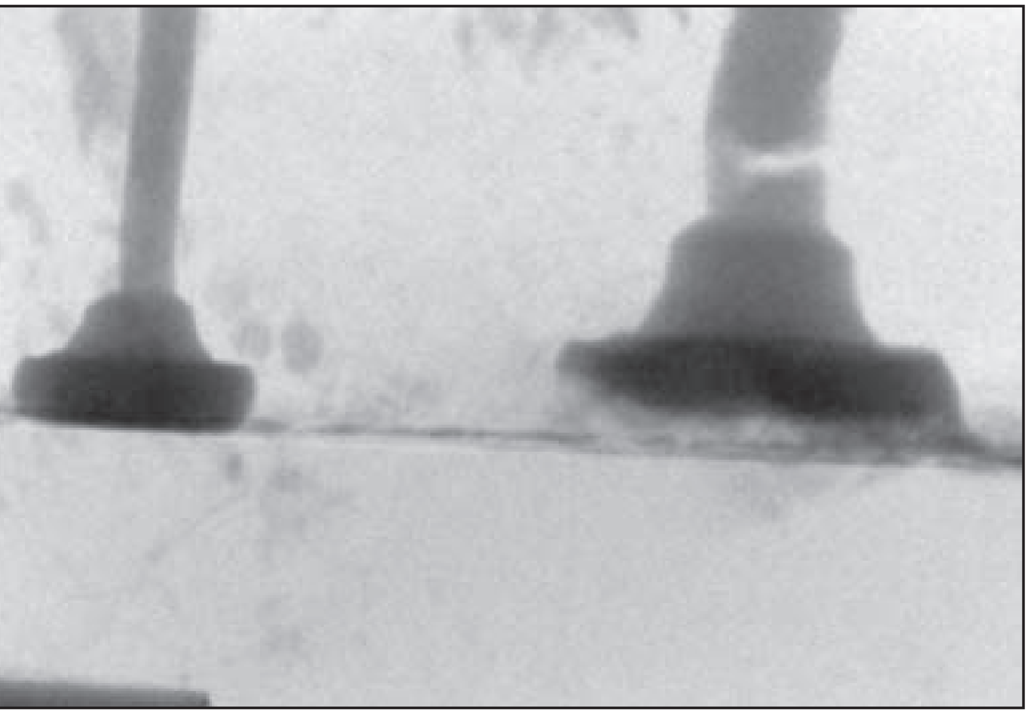
The phoenix|x-ray group of companies recently launched their new "bench|mate", the world´s first bench-top microfocus X-ray system that can be expanded with plug-in modules. With this highly innovative product the company adds a low-budget inspection tool to its range of equipment for non destructive failure analysis and process control.

The standard model comes with a 90 kV closed microfocus X-ray tube, a 100 kV tube is available upon request.

What makes the bench|mate unique is the possibility to add different tools and modules which can be easily installed without the need of a service engineer. With very little effort the system can thus be adapted to the requirements of specific inspection tasks.

Currently available options are e.g. a motorised x-y-z axis manipulation, a tilt-and-rotate unit, an image intensifier, the phoenix|x-ray high-contrast|set plus various image processing software plug-ins.

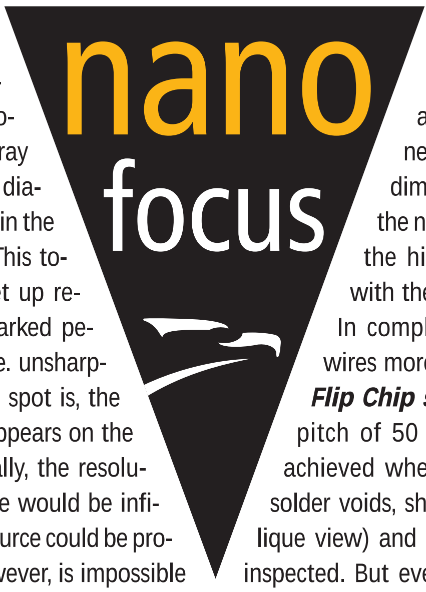
Due to its very compact dimensions of 63 x 44 x 55 cm (25 x 17.3 x 21.7 inch) and its small weight of 150 kg (330 lbs) the bench|mate is dedicated for the use in laboratories and smaller production plants with medium inspection quantities.



A new dimension of X-ray inspection - nanofocus technology

The System
Already in June 2001 phoenix|x-ray launched the first X-ray tube with a verified submicron resolution for industrial application and thus invaded new dimensions in X-ray image resolution and detail detectability. The nanofocus X-ray tube is available as an option for all systems of the analyser series. It can be operated in various power modes so that objects which require higher X-ray power in the microfocus range can be inspected, too.

The Technology
The image resolution of an X-ray system mainly depends on the size of the focal spot of the tube. For X-ray tubes available so far the diameter of the focal spot was in the range of several microns. This together with the system set up results in a more or less marked penumbra or half shadow, i.e. unsharpness. The smaller the focal spot is, the sharper the X-ray image appears on the detector. Hence, theoretically, the resolution of the projected image would be infinite if a punctiform X-ray source could be produced. In practice this, however, is impossible since any target material would be melting at the corresponding very high electron beam intensity.



Applications
nanofocus technology is a clear answer to the challenges X-ray inspection has to face through progressive miniaturisation in the electronics industries.
Microvias are an essential element of HDI multilayer boards. The vias reach diameters down to 25 microns so that possible defects may be even remarkably smaller. Shape deviations due to faulty drilling, for example, or metalisation failures may occur in the micron range or even below. Since contrast conditions may be also unfavourable because of the low absorption of the thin platings and oblique views may be necessary to inspect the three-dimensional shape of the vias, the nanofocus is compatible with the high-contrast|set as well as with the ovhm|modules.
In complex IC packages the bond wires more and more are replaced by ***Flip Chip solder joints***. Here, too, a pitch of 50 micron or less is already achieved whereas accumulation of tiny solder voids, shape deviations (also in oblique view) and the pad wetting has to be inspected. But even in classical ***bond wire*** interconnections, e.g., fatigue cracks at the bonds could be scarcely detected up to now because the cracks only open by a few microns and the wires are kept in position by the molding (see image above).

Generally spoken, every X-ray inspection which requires a high magnification and, consequently, calls for excellent image sharpness can be performed easier and at higher performance using the nanofocus tube.

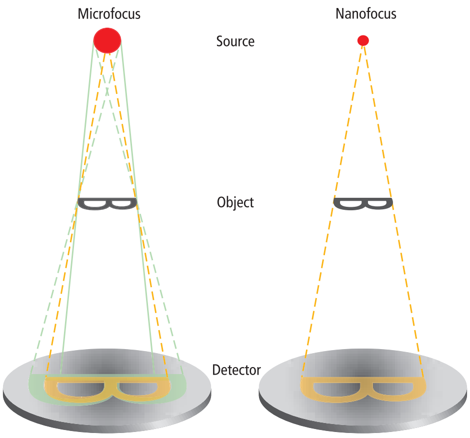
The new technology is treasured and actively applied in industry already: about 20% of all phoenix|x-ray tubes presently being delivered are of the nanofocus type.

Product specifications
package|analyser nf

Dimensions:	1500 x 1800 x 1100 mm
Weight:	1700 kg
Scanning area:	460 x 305 mm
Max. sample size:	560 x 405 mm
X-ray source:	Open nanofocus X-ray tube with transmission target
Max. tube current:	100/160 kV
Max. target power:	50 W
Min. focal spot size:	900 nm (0.9 µm)
Detail detectability:	300 nm (0.3µm)
Image chain:	6“single-field image intensifier with CCD-Camera
Image processing:	image|assistant
Auto positioning:	Standard
Tilt-rotate-unit:	Option
Leakage radiation:	<1µSv/h

What exactly is „sharpness"?

Frequently the achievable image "sharpness" is specified by quantities like resolution, focal spot size, detail detectability, etc., using these terms in a quite arbitrary way. The task of this article is to make clear the real meaning of such specifications by a basic consideration of the physical relations between them.



The image sharpness mainly depends on the size of the X-ray source. The geometric magnification is determined by the Source-Object-Distance.

To specify properly the **resolution** of an optical system an object of reference must be defined. In the case of an X-ray system a fine grid of alternating strongly and weakly absorbing lines with a grid period of length G is used. In practice this may be realised by gold stripes on a thin plastic substrate.

If such a grid is irradiated at high geometric magnification M (i.e. at small distance to the X-ray source) by X-ray sources of varying size, the image of the grid will be more and more blurred with increasing size F of the source until it vanishes finally. This process is described by the contrast transfer function (CTF). Experimentally, the CTF is determined by dividing the contrast of the grid image (measured for varied G) by the contrast of a very coarse grid of the same kind.

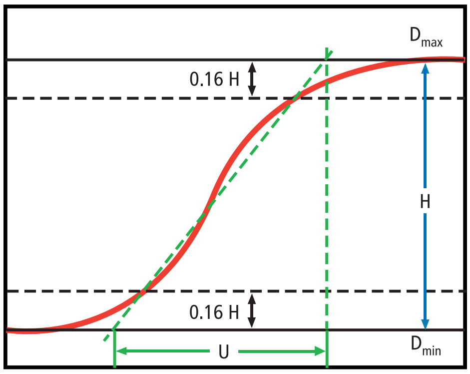
Mathematically it can be shown that the CTF at high magnification is exactly equal to zero if G=F(M-1)/M. Hence, the contrast vanishes when, at high magnification, the size of the X-ray source F reaches the *periodic length* G of the grid. (In practice the contrast vanishes slightly earlier because small intensity differences cannot be resolved by the human eye.) Vice versa, a set of grids of graduated periodic lengths may be used to determine the size of a given X-ray source by simply looking for the finest grid that can be imaged. The resolution then is specified by the periodic length of this grid in microns (µm) or its reciprocal, the line frequency of the grid in line pairs per millimeter (LP/mm). Thus, the measured resolution at high magnification is limited by the size of the X-ray source.

The X-rays of a microfocus tube mainly originate from the small area where the electrons hit the target. So the size of the X-ray source (i.e. the resolution limit) frequently is equated with the **focal spot size** of the tube. Incidentally, this simplification is not exactly valid for nanofocus tubes because for such small focal spots the size of the actual X-ray source also depends on the electron velocity, i.e., on the tube voltage.

Obviously, the concept of resolution by definition is closely linked with contrast (object quality) and magnification. So the size of the X-ray source or the focal spot size, which can be determined also by other methods, have become an established resolution specification for X-ray systems. For example a density trace across the image of a sharp edge in a radiograph may be measured by means of a densitometer and evaluated according to the below figure to yield the X-ray source size.

Other specifications are not as clearly defined by measuring procedures: **detail detectability**, for example, is used to describe the size of the smallest object to be still recognized by the system. Usually vendors assume it to be one half of the resolution in microns, i.e. the width of one grid space, or give even smaller values since non-periodic objects of high contrast would be still visible under certain circumstances.

Thus, evaluating system specifications, the definition of the quantities stated by the vendor should be closely scrutinized. In case of doubt the comparison should be restricted to resolution values. Detail detectability is a reasonable measure only if the specific reference object is considered, too.



Measurement of the focal spot size or rather the X-ray source size by the edge method. The unsharpness U is read from the densitometer trace across the edge as shown, and the magnification M is given by the system geometry. The focal spot size is F=U/(M-1)

Glossary

Contrast - A measure for intensity or brightness differences in an X-ray image. May be defined as $K=(I_{max}-I_{min})/(I_{max} + I_{min})$.

CTF - Contrast Transfer Function, a measure for the resolution and contrast capabilities of an X-ray system.

Detail Detectability - The size of the smallest object that can be recognised by an X-ray system.

Focal Spot Size - The approximately circular area on the target onto which the electron beam in the X-ray tube is focussed. The diameter of the focal spot predominantly determines the resolution since the X-radiation mainly originates from the focal spot.

Geometrical Magnification - Ratio of the source-detector-distance and the source-object-distance. The geometric magnification must be sufficiently large, so that the detector can recognise the object details to be displayed in the image.

high-contrast|detector - A digital detector consisting of scintillation foil and photo diode array. Its contrast resolution in a dynamic range of 65,000 grey values is four times better than that of an image intensifier.

Image Intensifier - An electron-optical device to convert the invisible X-ray image to visible light and to amplify its intensity. The image at the output screen of the image intensifier is recorded by a CCD camera.

Microfocus X-ray Tube - An X-ray tube with a focal spot size of less than 200 microns in the past, now in the range several microns.

nanofocus X-ray Tube - An X-ray tube with a focal spot in the nanometer range (1000 nm = 1 micron).

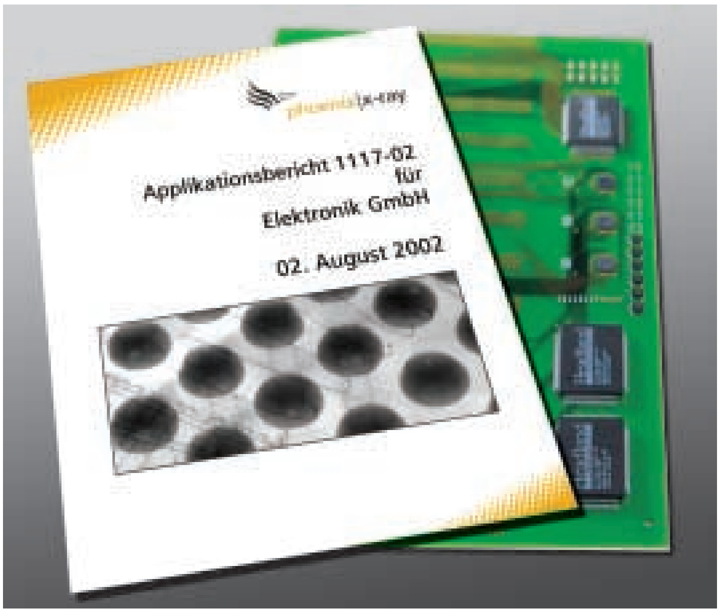
Resolution - The periodic length of the finest grid recognisable in the X-ray image.

Target - Material layer on the tube´s exit window onto which the electron beam in the source is focussed an in which the X-radiation is generated. Usually the target is made of tungsten because of the high X-ray yield and high melting point of this material.

X-ray Source - In a narrower sense: The area of the target where the X-radiation is generated.

application services

The laboratories listed at the right are offering application services for the non-destructive failure analysis with X-ray. Your samples will be inspected by a qualified phoenix|x-ray applications engineer, a dedicated application report will be worked out upon request. Alternatively the X-ray systems in the laboratories can be rented for your own inspections on a daily basis.



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The enterprise was founded in 1972 and is a renowned distributor of manufacturing and test equipment for the electronics industries in the area.

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Sistronics Ltda. is the youngest partner of phoenix|x-ray. The company, founded in 1985, holds exclusive sales rights for a number of well-known capital goods manufacturers for the Brasilian market including microfocus X-ray systems from phoenix|x-ray.

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OSTEC Enterprise Ltd. is a young Russian distributor which has been phoenix|x-ray´s agent for Russia since the year 2002. OSTEC Enterprise Ltd. is taking care of the customers in the fields of PCBA and semiconductor manufacturing.

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