Product Information
Version 1.0

ZEISS Xradia 810 Ultra

Nanoscale X-ray Imaging at the Speed of Science

We make it visible.

Extending the Reach of 3D X-ray Imaging

Xradia 810 Ultra
The only nanoscale
3D X-ray microscope

Xradia 810 Ultra increases the throughput of nanoscale, three-dimensional X-ray imaging by up to a factor of 10. This innovative X-ray microscope (XRM) operates at 5.4 keV, a lower energy that delivers better contrast and image quality for medium to low Z samples and other materials used throughout science and industry. Better contrast enables higher-quality tomographies to be acquired an order of magnitude faster while achieving resolution down to 50 nm.

ZEISS Xradia 810 Ultra: Highest resolution. Higher contrast. Faster.

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Non-destructive nanoscale imaging
ZEISS solutions deliver the world's only non-destructive X-ray imaging with resolution down to 50 nm. Along with both absorption and Zernike phase contrast, Xradia 810 Ultra employs advanced optics adapted from the synchrotron to deliver industry-best resolution and contrast. This innovative instrument adds a critical, non-destructive step to the traditional imaging workflow to promote breakthrough research in premier labs worldwide.

Superior contrast across a wider class of materials
By delivering higher contrast at 5.4 keV, Xradia 810 Ultra makes high-resolution X-ray imaging viable for a variety of difficult-to-image materials. Absorption and phase contrast optimize imaging for a diverse range of materials such as polymers, oxides, composites, fuel cells, geological samples and biological materials. Having pioneered nano-scale X-ray imaging at synchrotrons and prominent lab facilities worldwide, ZEISS solutions now optimize XRM for groundbreaking studies at the forefront of research.

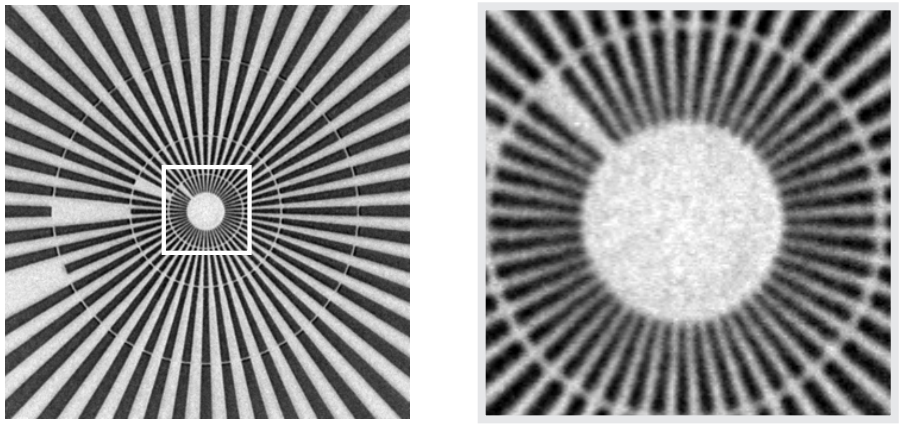
Extending the boundaries of science and industry
By making nanoscale X-ray imaging an order of magnitude faster, Xradia 810 Ultra optimizes the business case for XRM in both science and industry. For central microscopy labs, a faster workflow translates into more users being able to leverage the instrument in less time, which in turn extends XRM to a broader base of subscribers. Similarly, 4D and in situ studies of internal structure can be quickly performed and repeated, making these techniques viable in many more applications. And in targeted applications such as digital rock physics used to explore feasibility oil and gas extraction, Xradia 810 Ultra delivers measurements used to characterize critical parameters such as porosity within a matter of hours.

Your Insight into the Technology Behind It

Unique among laboratory-based microscopes, Xradia 810 Ultra leverages the penetration power of X-rays to deliver non-destructive 3D imaging with resolution down to 50 nm, the highest achievable by lab-based microscopes. Flexible contrast modes and unique X-ray optics provide unmatched versatility for a diverse array of applications and sample types.

Researchers have long recognized the potential of short wavelength X-rays for achieving high-resolution imaging in the nanometer range. For many years, however, the development of X-ray microscopes (XRM) that could realize this potential was hindered by the limited brightness of laboratory X-ray sources and the difficulty of fabricating suitable X-ray optics.

ZEISS's Xradia 810 Ultra employs optics adapted from synchrotron research to achieve the highest resolution of any laboratory X-ray microscope, down to 50 nm. By leveraging the non-destructive nature of X-rays, this microscope enables 3D nanoscale imaging for observing microstructural evolution over time (4D).



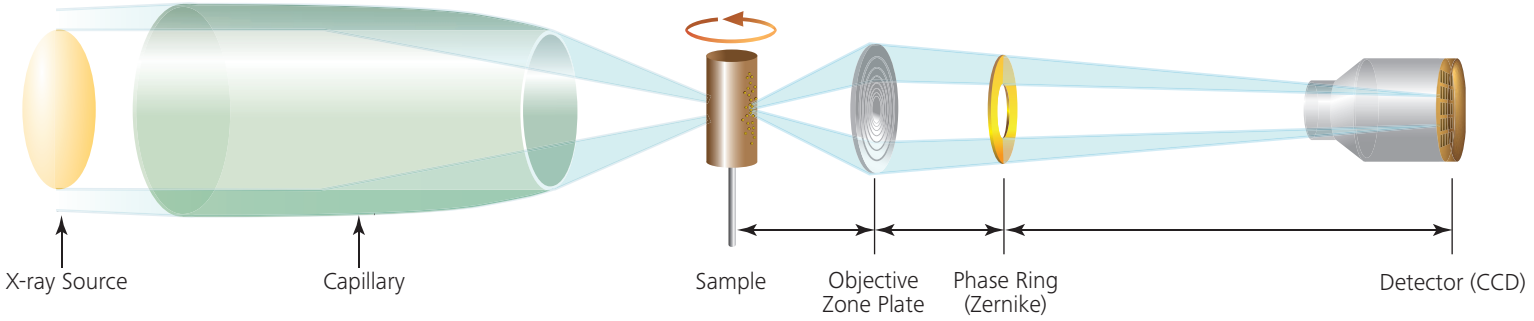
Resolution target: 50 nm lines and spaces

Your Insight into the Technology Behind It

Transmission X-ray Microscopy (TXM) Architecture

The architecture of Xradia 810 Ultra is conceptually equivalent to that of an optical or transmission electron microscope (TEM):

- A high-brightness X-ray source is focused onto the specimen by a high-efficiency capillary condenser
- Fresnel zone plate objectives image transmitted X-rays onto the detector
- An optional phase ring can be inserted into the beam path to achieve Zernike phase contrast for visualizing features in low-absorbing specimens
- As the specimen is rotated, images are collected over a range of projection angles that are then reconstructed into a 3D tomographic dataset



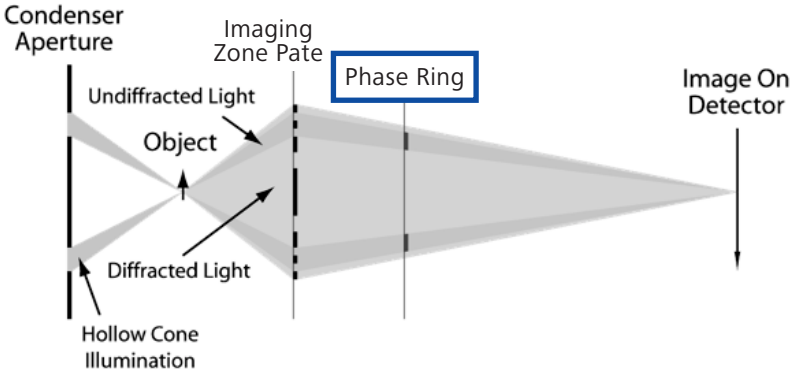
Your Insight into the Technology Behind It

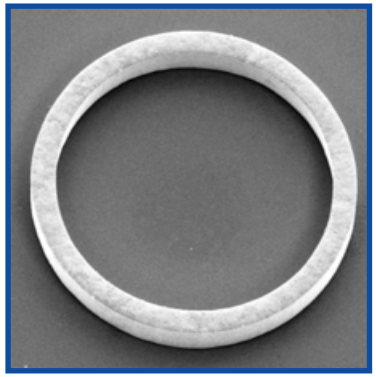
Contrast for diverse sample types

Xradia 810 Ultra offers both absorption and phase contrast to optimize visualization of features of interest in a wide range of samples.

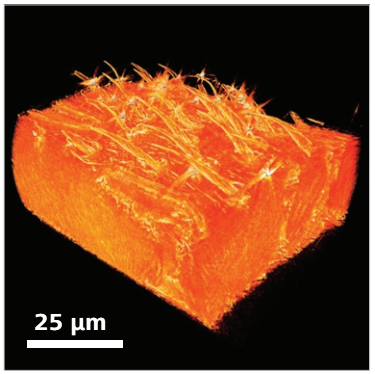
Absorption contrast imaging, essentially shadow or projection imaging, utilizes the varying attenuation power of different materials to generate contrast. It is best suited to specimens containing materials of varying density—for example, material and pore space.

Phase contrast imaging utilizes the refraction of X-rays rather than absorption. It is very sensitive to interfaces between materials of similar density or low absorption (edge enhancement). The Xradia Ultra family employs the Zernike method for phase contrast, whereby the sample is illuminated by an annular beam and a phase ring is inserted in the beam path after the objective. The phase ring shifts the phase of the background light relative to the light scattered by the specimen. The interference of the two beams in the detector plane turns phase shifts into intensity variations.

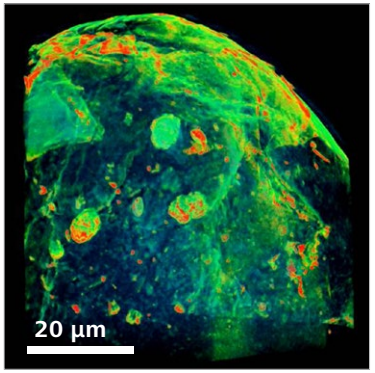




Phase Ring



3D view of a bee antennae imaged using phase contrast. Sample courtesy of University of Bristol



3D nanoscale view of a polyamide sample imaged using absorption contrast, exhibiting silica platelets. University of Wroclaw

Your Insight into the Technology Behind It

Choose X-ray energy to optimize contrast: 5.4 keV or 8.0 keV

In XRM, contrast depends on the material being imaged and the X-ray energy used. The Xradia Ultra family comprises Xradia 800 Ultra, operating at 8 keV photon energy, and Xradia 810 Ultra, operating at 5.4 keV. In general, lower energy X-rays are absorbed more strongly and therefore provide higher contrast. Thus, as long as transmission remains sufficient, the resulting image quality and/or throughput are greatly improved with Xradia 810 Ultra. For materials of higher density, or thick specimens, the higher X-ray energy of Xradia 800 Ultra may be needed to provide sufficient transmission.

Segment	Application	Xradia 810 Ultra 5.4 keV	Xradia 800 Ultra 8.0 keV
Materials Science	Polymers	preferred	■
	Ceramics*	■	■
	Metals*	■	■
	Composites*	■	■
	SOFC		■
	Batteries*	■	■
Natural Resources	Carbonate	preferred	■
	Shale	preferred	■
Life Sciences	Soft tissue	preferred	■
	Calcified tissue	preferred	■
	Bio scaffolds	preferred	■
Semiconductor	TSV	■	preferred

Preferred = optimal choice for higher throughput and contrast

*Dependent on the exact material within these materials classes, either 5.4 or 8 may be preferred

Your Insight into the Technology Behind It

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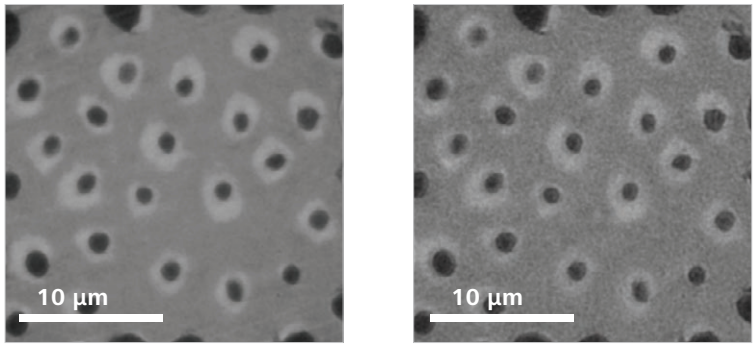
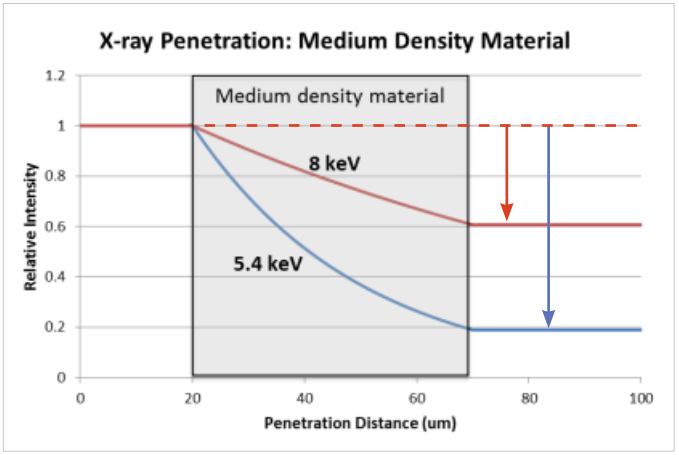
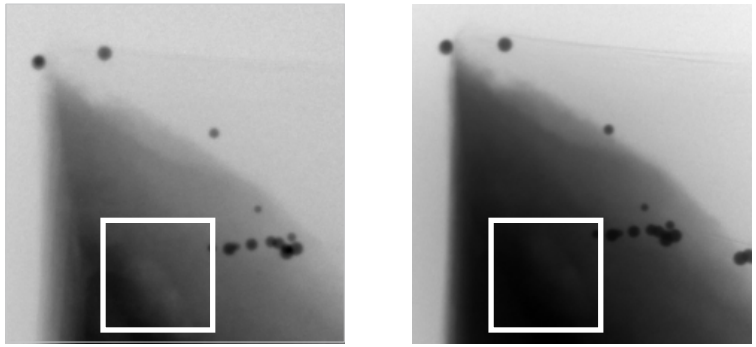


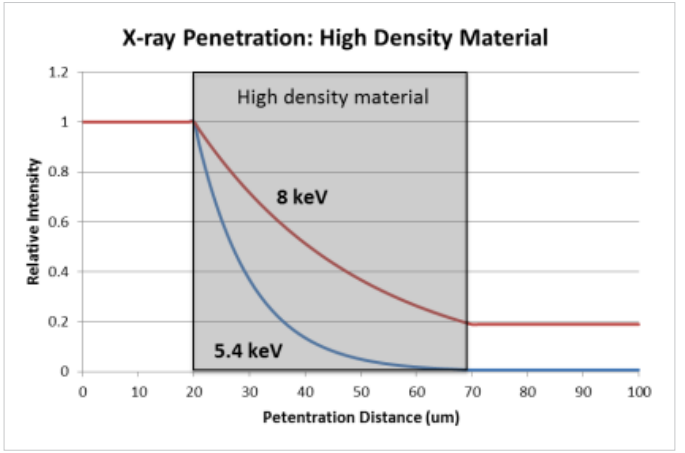
Dentin imaged at 5.4 keV, left, and 8.0 keV, right. At 5.4 keV, image quality is equivalent while acquisition is 10 times faster due to optimized contrast



Greater intensity drop at 5.4 keV leads to higher contrast



Example where the greater penetration at 8 keV is beneficial. In the highlighted region, transmission of 5.4 keV X-rays is too low to detect variations in local density.



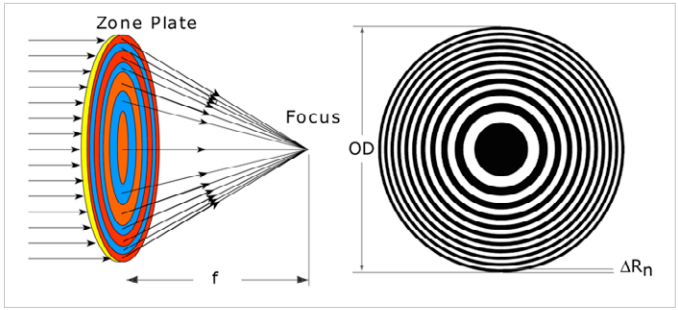
Transmission at 5.4 keV is insufficient to discern small variations

Your Insight into the Technology Behind It

Unique X-ray Optics

For X-rays, traditional light or electron optics schemes are not suitable because refraction is extremely weak and X-rays do not get deflected in magnetic fields. Instead, Xradia 810 Ultra employs proprietary X-ray optics originally developed at synchrotron facilities and optimized by ZEISS for a wide variety of lab-based applications. Highlights include:

- Reflective capillary condensers, precision-fabricated to match source properties and imaging optics at maximum flux density;
- Fresnel zone plates, circular diffraction gratings used as objective lenses. Maintaining high resolution and high efficiency requires both very narrow and tall ring structures, leading to a high-aspect ratio construction, a significant challenge in nanofabrication technology. This is addressed by multiple ZEISS patents and years of experience aligning and integrating high-quality optics;
- Phase rings for Zernike phase contrast;
- High contrast and efficiency detectors based on scintillators, optically coupled to a CCD detector.



Schematic of a Fresnel zone plate

Scanning Electron Micrograph of a Fresnel Zone Plate

Capillary condenser

Tailored Precisely to Your Applications

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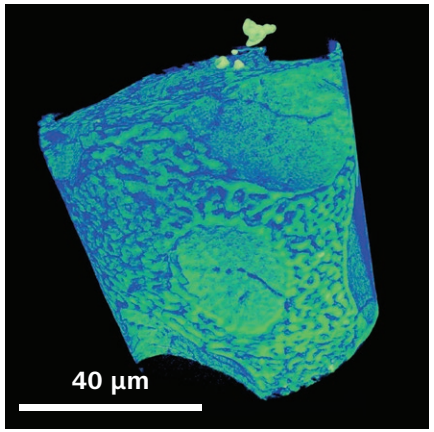
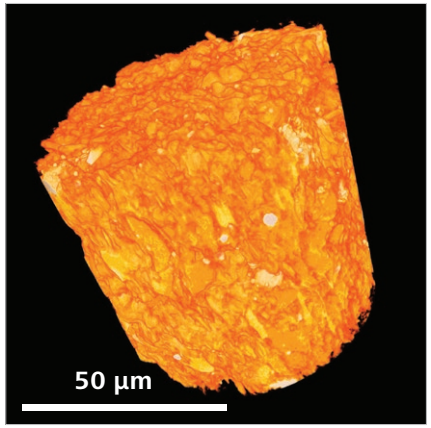
Typical Applications	Task	Xradia 810 Ultra offers
Oil & Gas	Virtual core analysis	Nanoscale pore structure measurements for geological samples can now be conducted in a few hours
Material Science	Study and predict material properties and evolution Measure and identify porosity, cracks, phase distribution etc.	Non-destructive, high resolution 4D and *in situ* studies can now be performed in hours as opposed to more than 1 day
Life Sciences	Examine both hard and soft tissue	Superior contrast, nanoscale 3D X-ray imaging of a variety of bio materials such as polymers for drug delivery, tissue samples, and scaffolds for tissue engineering
Semiconductor	Process optimization and defect characterization for wafer-level packaging	Through-silicon via (TSV), MEMS, and failure analysis of interconnects

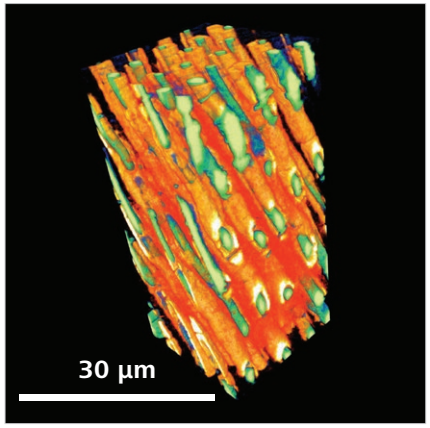
ZEISS Xradia 810 Ultra at Work



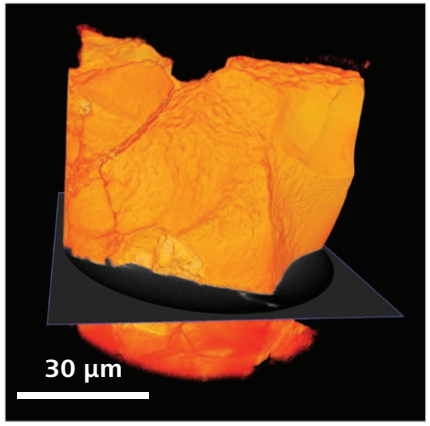
Al-Cu eutectic alloy: determine dendritic structure at ROI



Shale: rapidly determine internal porosity at nanoscale resolution



Dentin: 4D study of tubule occlusion



Carbonate: pore network characterization

Your Flexible Imaging Solution

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1 X-ray Microscope
- ZEISS Xradia 810 Ultra
- 50 nm spatial resolution for synchrotron-quality imaging in the laboratory

2 X-ray Source Options
- High brightness x-ray source
- 5.4 keV x-ray energy

3 X-ray Optics
- High efficiency condenser
- High resolution, high efficiency zone plate objectives
- Phase contrast optics (optional)

4 Detector System
- Optically coupled scintillator with high resolution and sensitivity

5 Workstation and Software
- Powerful workstation with GPU-based reconstruction
- XMController for data acquisition
- XMReconstructor for tomographic reconstruction
- XM3DViewer for 3D visualization
- Compatible with a wide range of 3D viewers and analysis programs

6 Microscope architecture for stability, flexibility and ease of use
- Vibration isolation and thermal control
- Ability to integrate *in situ* stages
- Integrated visible light microscope for sample inspection and alignment

Technical Specifications

Xradia 810 Ultra
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Imaging	**High Resolution Mode (HRES)**	**Large Field of View Mode (LFOV)**
Spatial resolution	50 nm	150 nm
Field of View	16 µm	65 µm
Voxel size	16 nm	64 nm
Magnification	800x	200x

Contrast Modes	
Absorption Contrast	Standard
Phase contrast	Optional

X-ray Source	**Xradia 810 Ultra**	**Xradia 800 Ultra**
Source type	Rotating Anode	Rotating Anode
Target Material	Chromium	Copper
X-ray Photon Energy	5.4 keV	8.0 keV
Voltage	35 keV	40 keV
Power	0.9 kW	1.2 kW

Sample Stage	
Travel (x, y, z)	12, 8, 12 mm
Rotation	280°
Load capacity	1 kg

Features	**Xradia 810 Ultra**	**Xradia 800 Ultra**
Automated image alignment for tomographic reconstruction*	HRES and LFOV modes	LFOV mode
Integrated visible light microscope	■	■
GPU based tomographic reconstruction	■	■
Comprehensive software suite for data acquisition, reconstruction and visualization	■	■

* Sufficient room temperature and sample stability required

Count on Service in the True Sense of the Word

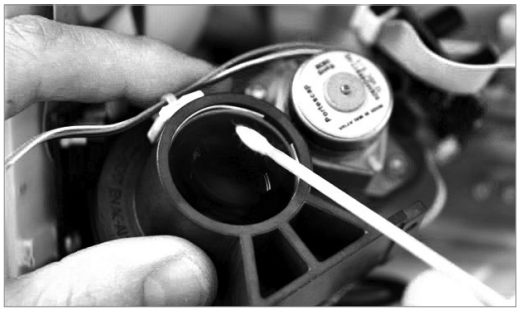
Because the ZEISS microscope system is one of your most important tools, we make sure it is always ready to perform. What's more, we'll see to it that you are employing all the options that get the best from your microscope. You can choose from a range of service products, each delivered by highly qualified ZEISS specialists who will support you long beyond the purchase of your system. Our aim is to enable you to experience those special moments that inspire your work.

Repair. Maintain. Optimize.
Attain maximum uptime with your microscope. A ZEISS maintenance contract lets you budget for operating costs, all the while avoiding costly downtime and achieving the best results through the improved performance of your system. Choose from service contracts designed to give you a range of options and control levels. We'll work with you to select the service program that addresses your system needs and usage requirements, in line with your organization's standard practices.

Our standard preventative maintenance and repair on demand contracts also bring you distinct advantages. ZEISS service staff will analyze any problem at hand and resolve it – whether using remote maintenance software or working on site.

Enhance Your Microscope System
Your ZEISS microscope system is designed for a variety of updates. As a result you'll work more efficiently now, while extending the productive lifetime of your microscope as new update possibilities come on stream.

Please note that our service products are always being adjusted to meet market needs and may be subject to change.



Profit from the optimized performance of your microscope system with a Carl Zeiss service contract – now and for years to come.

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The moment "I think" becomes "I know".

This is the moment we work for.

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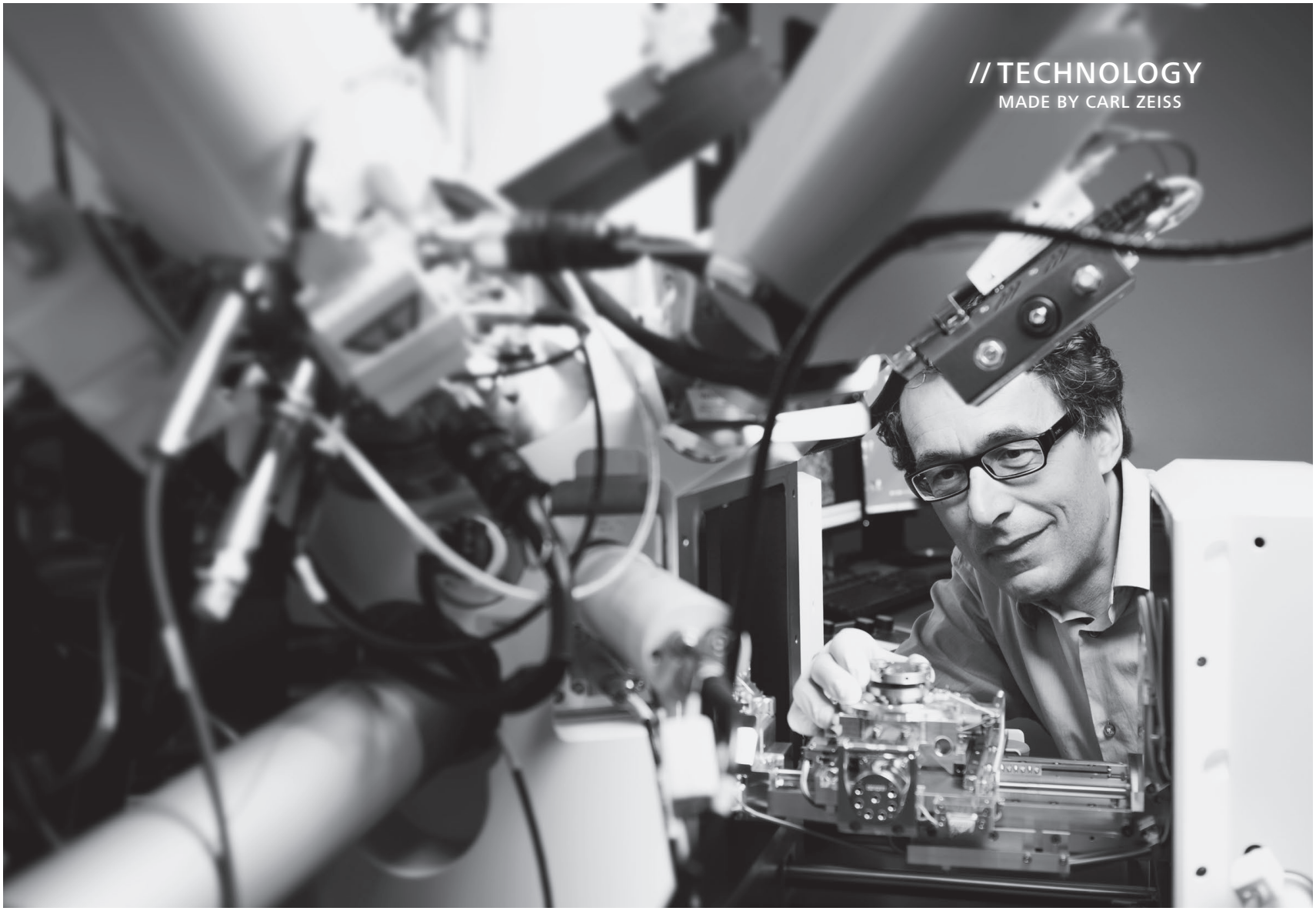

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