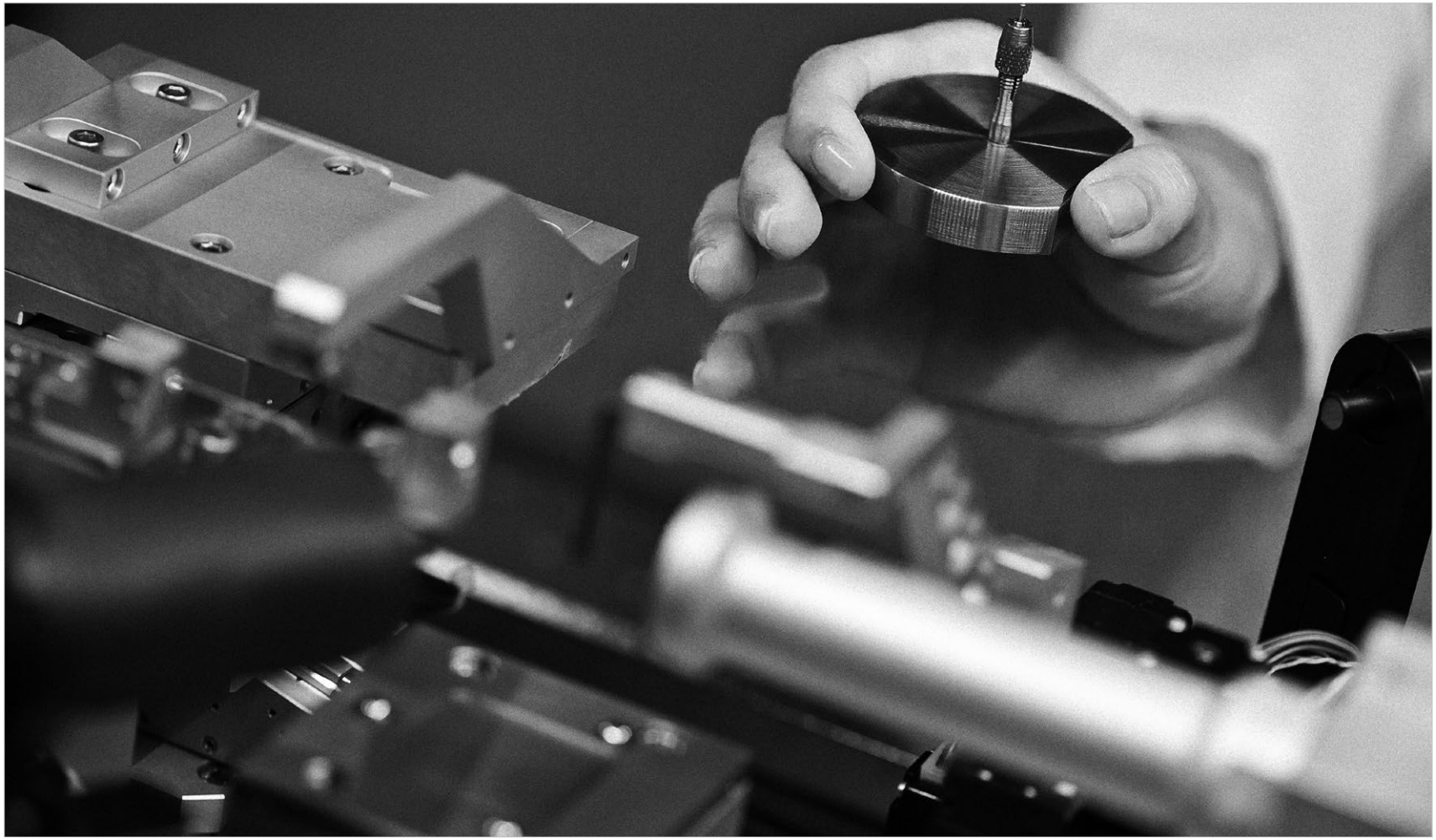


Product Information
Version 3.0

ZEISS Xradia 800 Ultra

Nanoscale X-ray Imaging:
Experience Synchroton-like Performance in the Lab

We make it visible.

Achieve Resolution Down to 50 nm

With the ZEISS Xradia 800 Ultra X-ray microscope, you achieve spatial resolution down to 50 nm, the highest among lab-based X-ray imaging systems. With non-destructive 3D imaging playing a vital role in today's breakthrough research, you will experience unparalleled performance and flexibility in the lab. The innovative Xradia Ultra architecture features absorption and phase contrast, X-ray energy of 8 keV, and unique optics adapted from the synchrotron. With Xradia 800 Ultra, expect to accomplish unrivaled *in situ* and 4D capabilities for studying material evolution over time and extends the limits of X-ray imaging used in materials science, life sciences, natural resources, and diverse industrial applications.

Simpler. More Intelligent. More Integrated.

Perform Non-destructive and *In Situ* Imaging

ZEISS Xradia 800 Ultra delivers reliable internal 3D information otherwise only accessible to you with destructive methods like cross-sectioning. The large working distance and atmospheric sample environment allow you to perform *in situ* studies with ease.

Achieve Unsurpassed Resolution

With resolution as fine as 50 nm, Xradia 800 Ultra provides you with insight into microscopic structures and processes previously not accessible with conventional lab-based X-ray technology. Operating with 8 keV X-ray provides excellent penetration and contrast for a wide range of materials, enabling you to observe structures and materials in their natural state.

Experience Unparalleled Contrast for Soft Materials

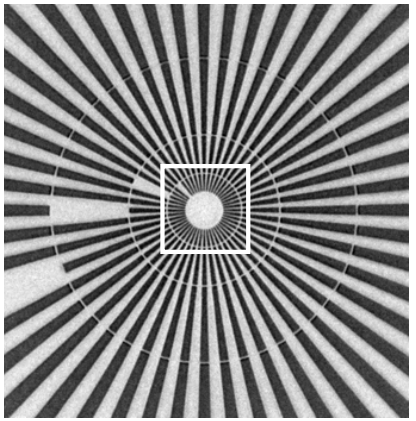
ZEISS Xradia integrated phase contrast technology employing the Zernike method allows enhanced visibility of grain boundaries and material interfaces when absorption contrast is low, providing you with visibility of ultra- and nano-structures without staining.

Your Insight into the Technology Behind It

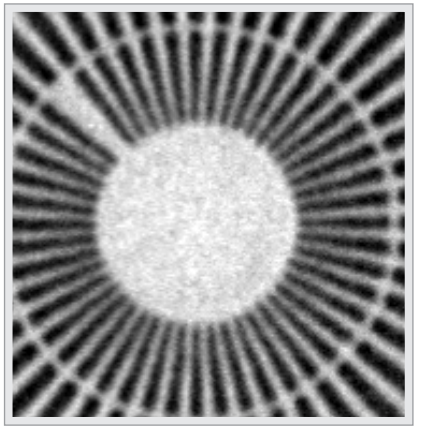
Unique among laboratory-based microscopes, Xradia 800 Ultra enables you to leverage the penetrating power of X-rays to accomplish non-destructive 3D imaging with resolution down to 50 nm, the highest achievable by lab-based microscopes. Flexible contrast modes and unique X-ray optics provide you with 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 Xradia 800 Ultra employs optics adapted from synchrotron research to enable you to leverage the non-destructive nature of X-rays to accomplish 3D nanoscale imaging and observe microstructural evolution over time (4D).



Resolution target: 50 nm lines and spaces

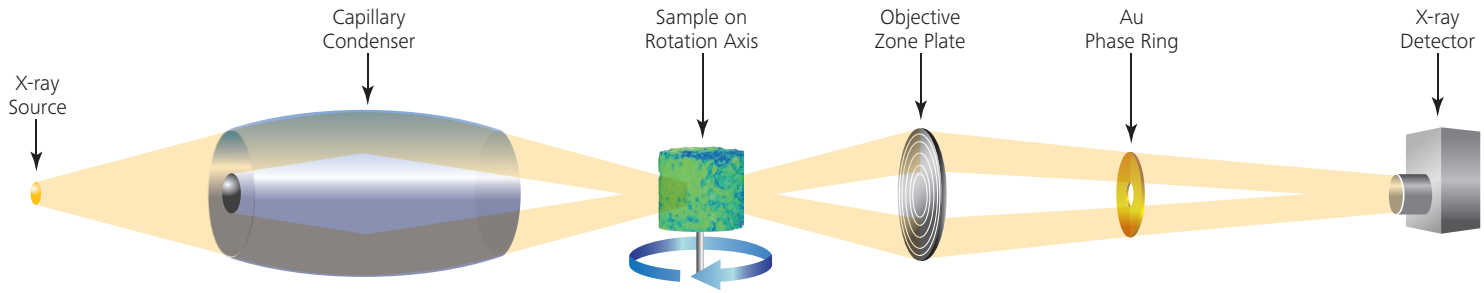


Your Insight into the Technology Behind It

Transmission X-ray Microscopy (TXM) Architecture

The architecture of Xradia 800 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
- You can insert an optional phase ring into the beam path to achieve Zernike phase contrast to visualize features in low-absorbing specimens
- As the specimen is rotated, you will collect images over a range of projection angles that you can then reconstruct into a 3D tomographic dataset



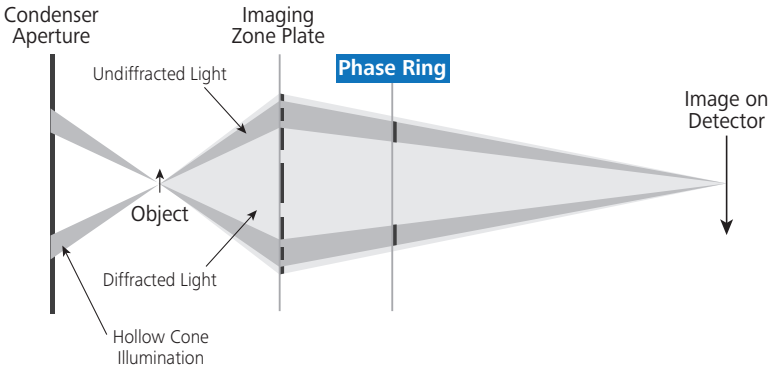
Your Insight into the Technology Behind It

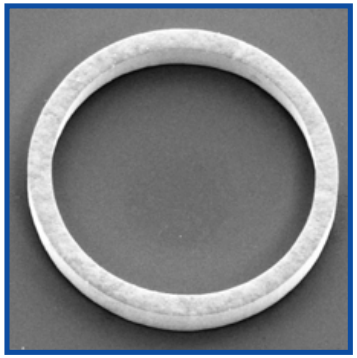
Contrast for diverse sample types

Xradia 800 Ultra offers both absorption and phase contrast to optimize your ability to visualize features of interest in a wide range of samples.

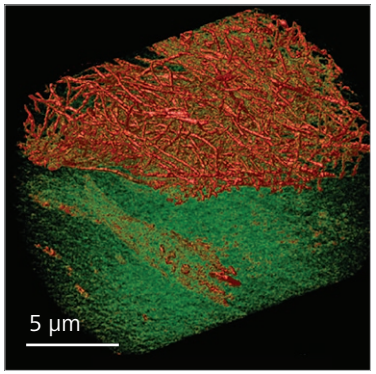
Absorption contrast imaging, essentially shadow or projection imaging, utilizes the varying attenuation power of different materials to generate contrast. It is best suited to your specimens that contain materials of varying density—for example, material and pore space.

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 enables you to employ 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.

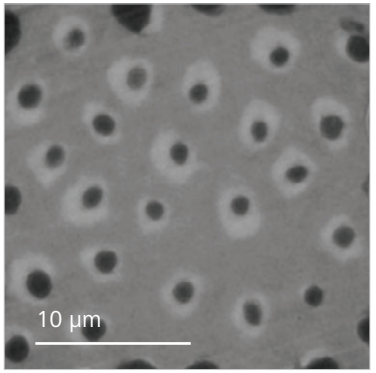




Phase Ring



Polymer fibers in a desalination membrane, imaged in phase contrast.
Sample courtesy of Industrial Technology Research Institute, Taiwan



Microtubules in dentin, imaged in absorption contrast.

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 will provide you with higher contrast. Thus, as long as transmission remains sufficient, you will experience resulting image quality and/or throughput that are greatly improved with Xradia 810 Ultra. For materials of higher density, or thick specimens, you may need the higher X-ray energy of Xradia 800 Ultra for sufficient transmission.

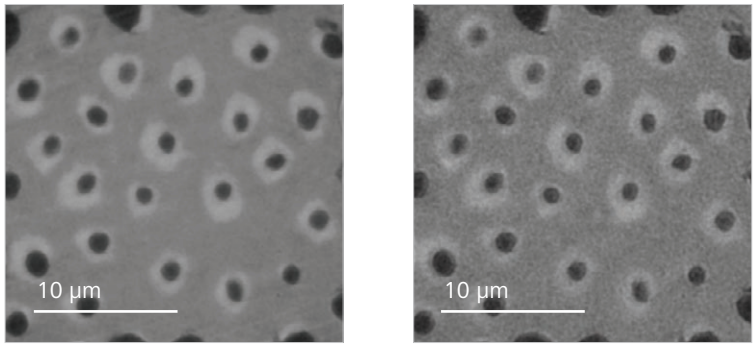
Segment	Application	Xradia 810 Ultra 5.4 keV	Xradia 800 Ultra 8.0 keV
Materials Research	Polymers	preferred	■
	Ceramics*	■	■
	Metals*	■	■
	Composites*	■	■
	SOFC	■	■
	Batteries*	■	■
Natural Resources	Carbonate	preferred	■
	Shale	preferred	■
Life Sciences	Soft tissue	preferred	■
	Calcified tissue	preferred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

Preferred = optimal choice for higher throughput and contrast

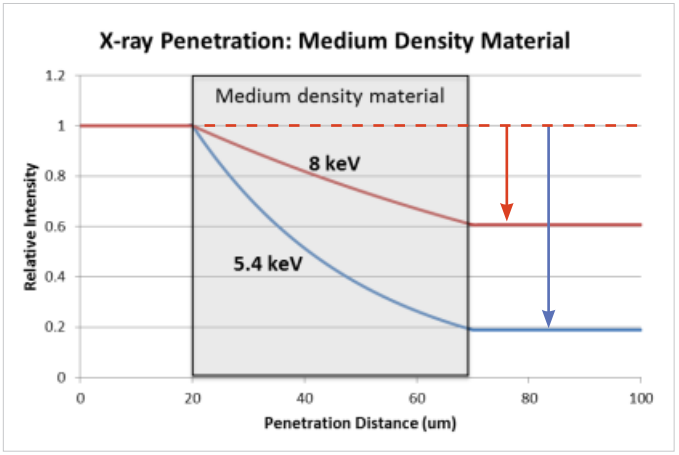
*Dependent on the exact material within these materials classes, either 5.4 or 8 may be preferred

Your Insight into the Technology Behind It

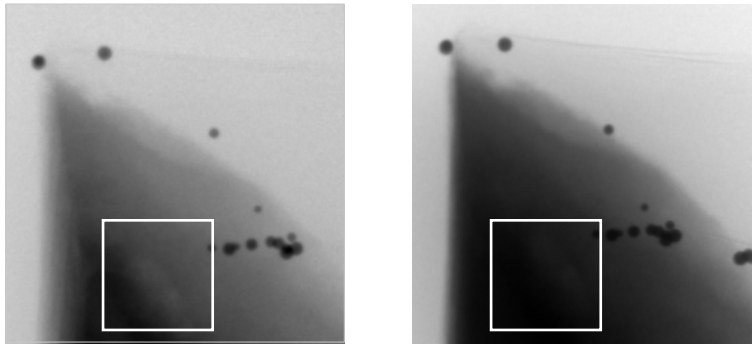
Choose X-ray energy to optimize contrast: 5.4 keV or 8.0 keV



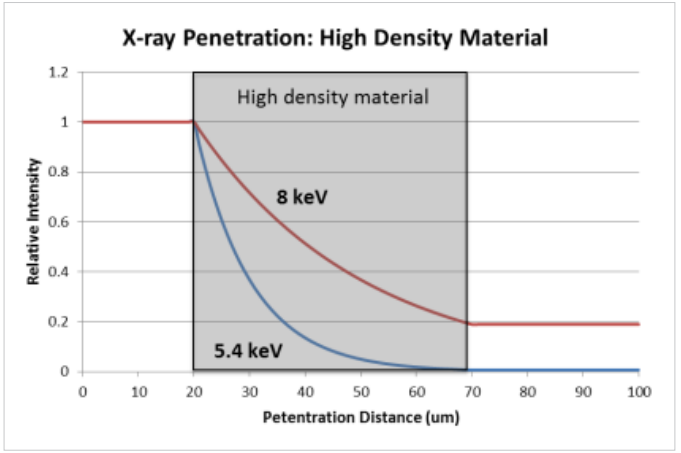
Dentin imaged at 5.4 keV, left, and 8.0 keV, right. At 5.4 keV, image quality is equivalent while acquisition is 10 times faster due to optimized contrast



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.

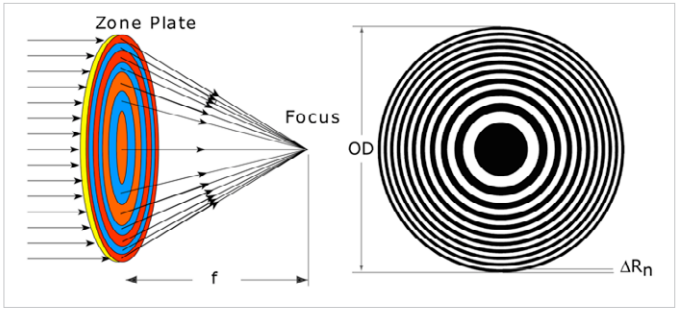


Transmission at 5.4 keV is insufficient to discern small variations

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 are not deflected in magnetic fields. Instead, Xradia 800 Ultra employs proprietary X-ray optics originally developed at synchrotron facilities and optimized by ZEISS for a wide variety of your lab-based applications.

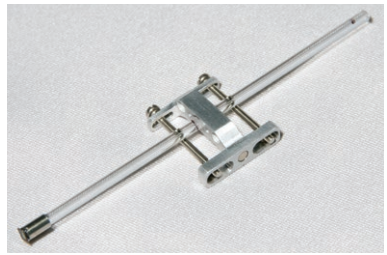


Schematic of a Fresnel zone plate

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. Multiple ZEISS patents and years of experience in nanofabrication provide the highest resolution and focusing efficiency optics for your research
- Phase rings for Zernike phase contrast
- High contrast and efficiency detectors based on scintillators are optically coupled to a CCD detector

Scanning Electron Micrograph of a Fresnel Zone Plate

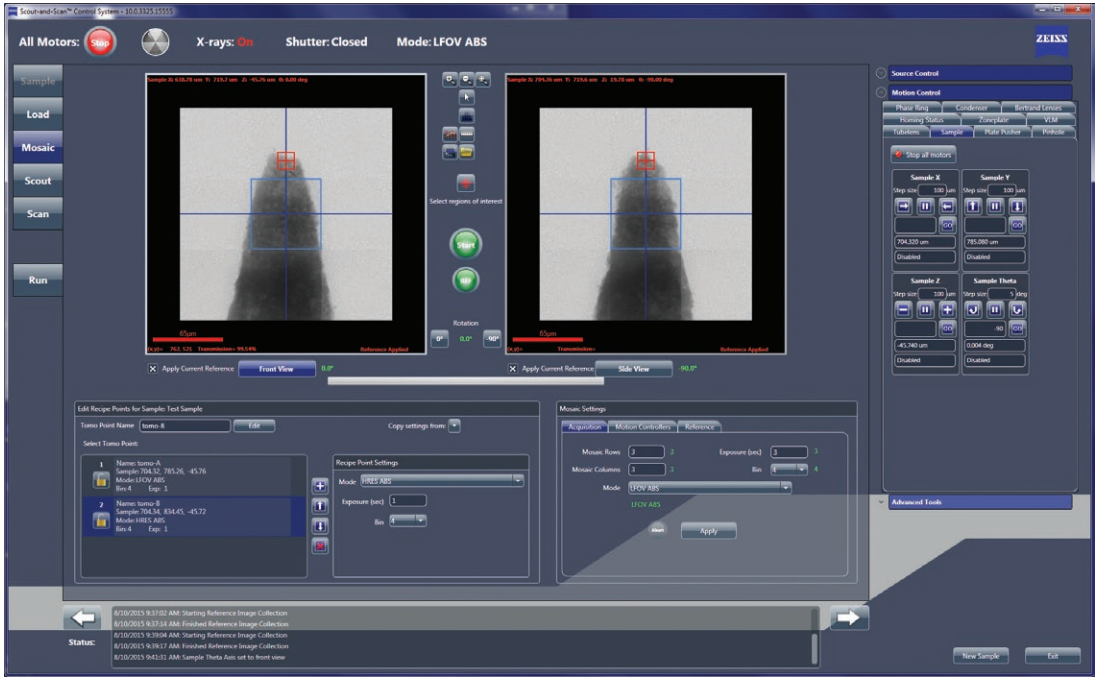


Capillary condenser

Your Insight into the Technology Behind It

User-friendly software to create efficient workflows

ZEISS's innovative Scout-and-Scan™ Control System streamlines sample and scan setup to boost your productivity with Xradia Ultra. The workflow-based user interface guides you through the process of aligning the sample, scouting for regions of interest, and setting up 3D scans. Recipes allow you to set up multiple scans of the same sample to image various regions of interest, or to combine different imaging modes. The easy-to-use system is ideal for a central lab-type setting where users may have a wide variety of experience levels.



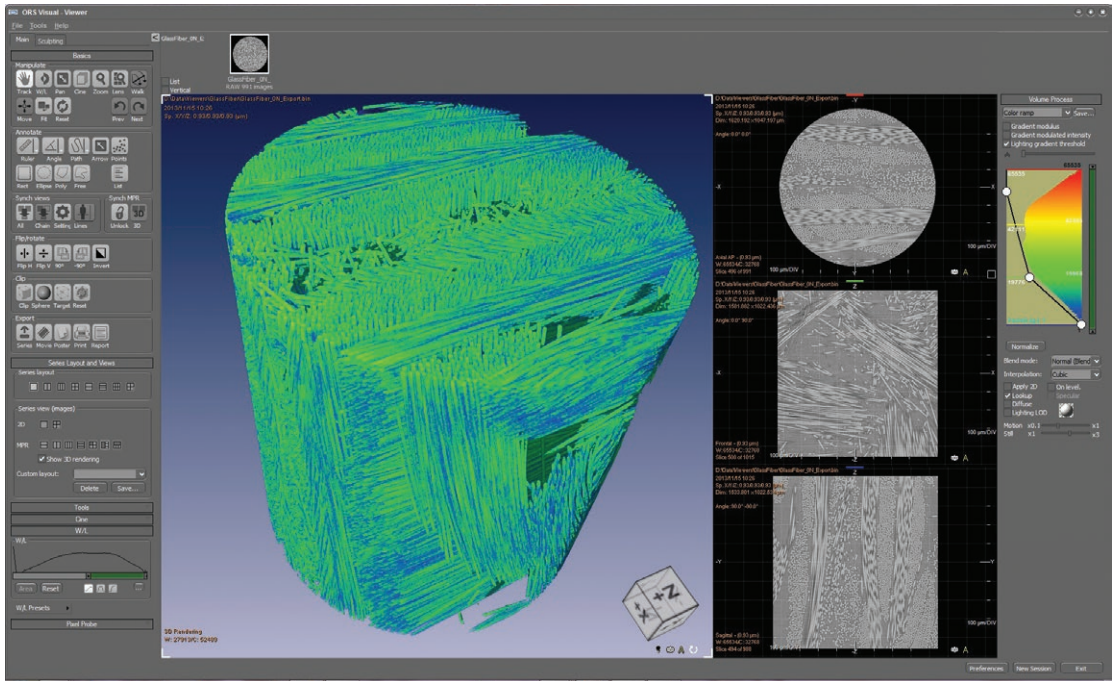
Set, Load, Scout, Scan, Run. It's that simple.

Your Insight into the Technology Behind It

Visual SI Advanced: Your Visual Pathway to Quantitative Answers

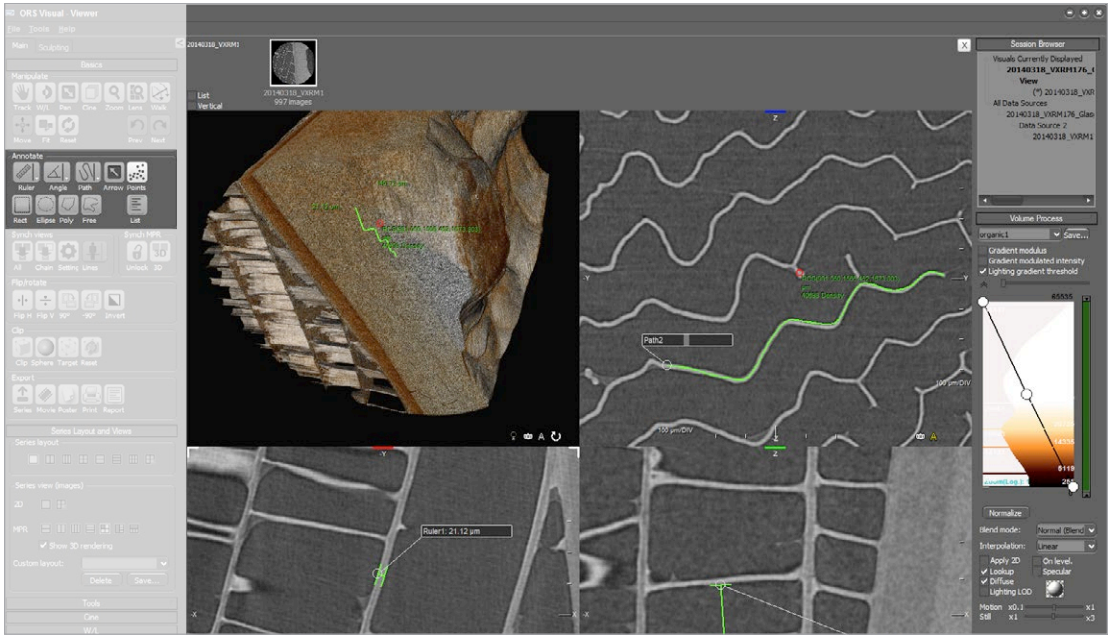
Visual SI Advanced is advanced 3D visualization and analysis software from Object Research Systems (ORS), and offered exclusively by ZEISS for processing SEM, FIB-SEM, and XRM data. Using advanced visualization techniques and state-of-the-art volume rendering, Visual SI Advanced enables high definition exploration into the details and properties of your datasets. You can register multiple datasets within the same workspace, and easily manipulate your 2D and 3D data with an extensive image processing feature set.

Segment your data automatically or manually in order to distinguish and visualize different materials. Visual SI Advanced is equipped with powerful object analysis functions to measure properties, including areas, volumes, counts, distributions, and orientations. The interface is designed to intuitively interact with statistical results, allowing you to precisely isolate and analyze specific regions of interest within your data.

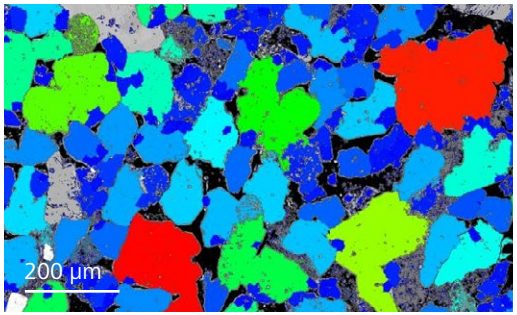


Your Insight into the Technology Behind It

Visual SI Advanced is a configurable software package. You can tailor the tools that are optimal to your workflow, and choose from plug-ins that allow you to control registration, map differences, and customize appearance. Visual SI Advanced also supports regular and unstructured surface meshes, and contains advanced editing tools to create regions of interest from a mesh and vice-versa. With the Plug-In Development Kit (PDK), you can leverage the Visual SI Advanced core technology to quickly build specialized workflows.



Advanced measurement tool: Measurement and annotation of Cuttlefish bone. Imaged with ZEISS Xradia Versa. Sample courtesy of Glasgow University



Compute morphometric properties to visualize quantitative answers: Sandstone imaged by SEM showing volume distribution of grains in sandstone. Courtesy of Imperial College

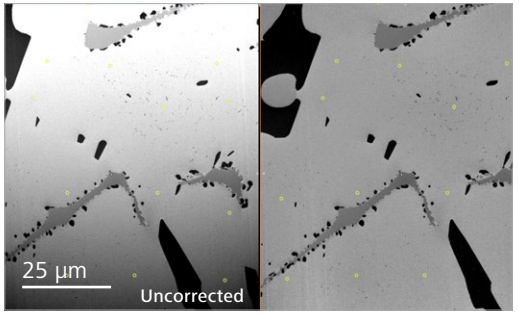


Image filtering: Correct shading, denoise. Nickel carbide alloy imaged by Crossbeam FIB-SEM. Dataset courtesy of P. Bala, AGH University.

Your Insight into the Technology Behind It
Accessories for Xradia Ultra

Xradia Ultra Load Stage

Xradia Ultra Load Stage uniquely enables *in situ* nanomechanical testing—compression, tension, indentation—with non-destructive 3D imaging. Study the evolution of interior structures in 3D, under load, down to 50 nm resolution. Understand how deformation events and failure relate to local nanoscale features. Complement existing mechanical testing methods to gain insight into behavior across multiple length scales.

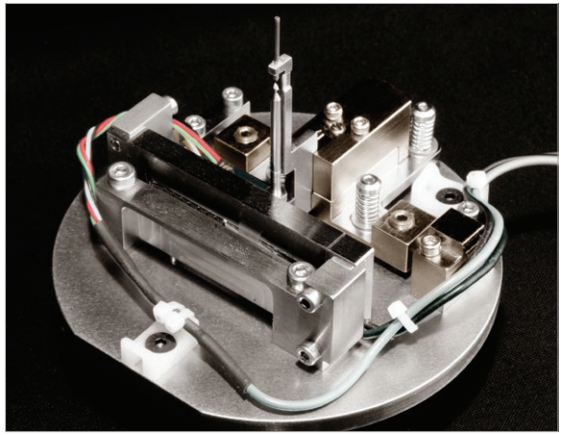
Combine X-ray vision with nanomechanical testing
Visualize and quantify 3D nanostructure as it changes under load

Explore a new length scale
Bridge the gap between the micron scale and established nanomechanical testing methods for SEM or TEM

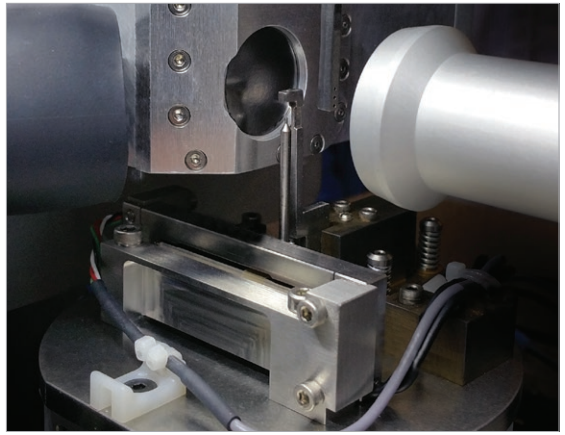
Study the behavior of bulk material on the nanoscale
Image internal structure and achieve resolution down to 50 nm on samples large enough to minimize surface effects typically present in extremely thin TEM samples

Key benefits

- Add *in situ* nanomechanical testing capabilities to your Xradia Ultra nanoscale 3D X-ray microscope (XRM)
- Acquire 3D tomograms of your sample under load with resolution down to 50 nm
- Perform a variety of nanomechanical tests such as compression, tension, and indentation
- Study a wide range of materials including metals, ceramics, composites, polymers and biomaterials
- Complement your mechanical test results from electron microscopy, microCT and stand-alone test set-ups to understand behavior across multiple length scales: from the atomic level and the nanoscale to the micro and macro scale.



Xradia Ultra Load Stage



Xradia Ultra Load Stage installed in Xradia Ultra 3D X-ray Microscope

Your Insight into the Technology Behind It
Accessories for Xradia Ultra

Xradia Ultra Load Stage

How does it work?

Xradia Ultra Load Stage is an *in situ* nanomechanical test stage for Xradia Ultra 3D XRM. It comprises a piezomechanical actuator with closed loop position control, a strain gauge force sensor and sets of top and bottom anvils that can be configured for three different operating modes:

- Compression: Observe deformation and failure of materials under uniaxial compressive load. Study elastic and plastic deformation and determine if the effects are uniform, anisotropic or localized relative to nanostructural features such as voids, struts or interfaces.
- Tension: Observe deformation and failure of materials under uniaxial tensile load. Understand critical properties like elastic modulus and tensile yield strength and how they relate to the specific nanostructural features of the specimen.
- Indentation: Study isolated deformation and failure events surrounding the indentation site. Understand crack generation and propagation, or delamination of coatings and layered structures.

Acquire 3D tomograms at various load stages in static condition. In between, acquire 2D projection sequences at shorter time intervals. The software interface allows control of displacement, read back of force, programmed displacement ramps, data logging and plotting.

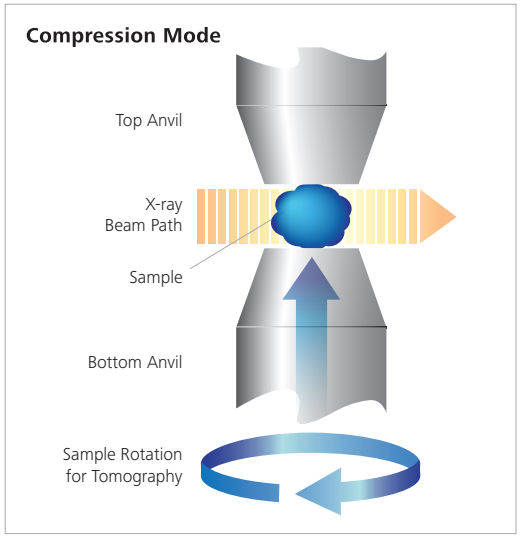
Anvils are configurable to accommodate different operating modes and experiments. The standard anvil set includes the following:

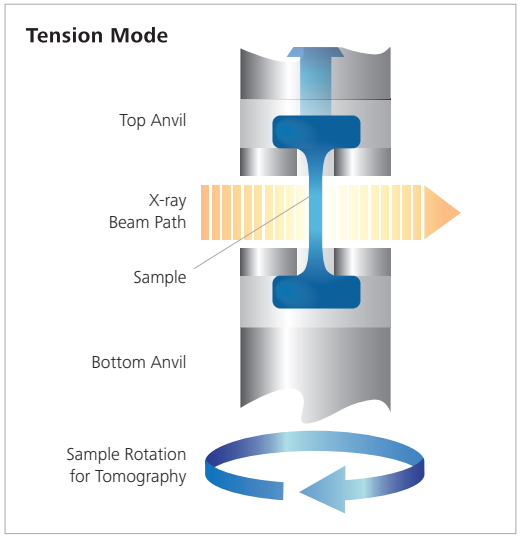
- Compression anvil: 100 µm diamond flat
- Tension anvil
- Diamond-tip indentation anvils: 90° cone, cube corner and wedge

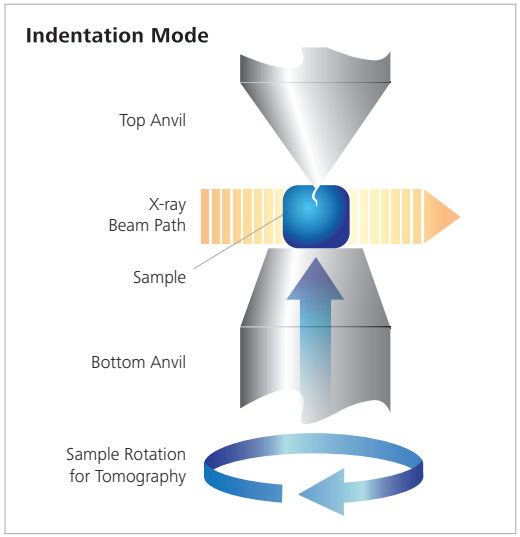
User-designed anvils can also be integrated for custom experiments.

Two different load cell versions are available:

- LS108: 0.8 N max force
- LS190: 9 N max force







Your Insight into the Technology Behind It
Accessories for Xradia Ultra

Xradia Ultra Load Stage

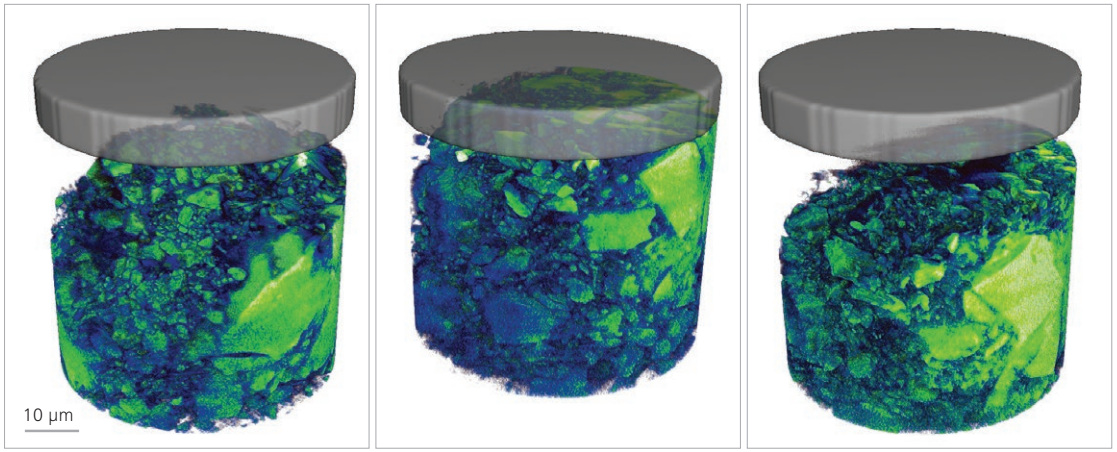
Key applications

In situ nanomechanical testing is relevant for a broad range of applications covering both engineered and natural materials.

Examples include:

- High strength alloys
- Building materials
- Fibers / composites
- Biomaterials / biomechanics
- Coatings
- Foams

Application example: compression of elastomer



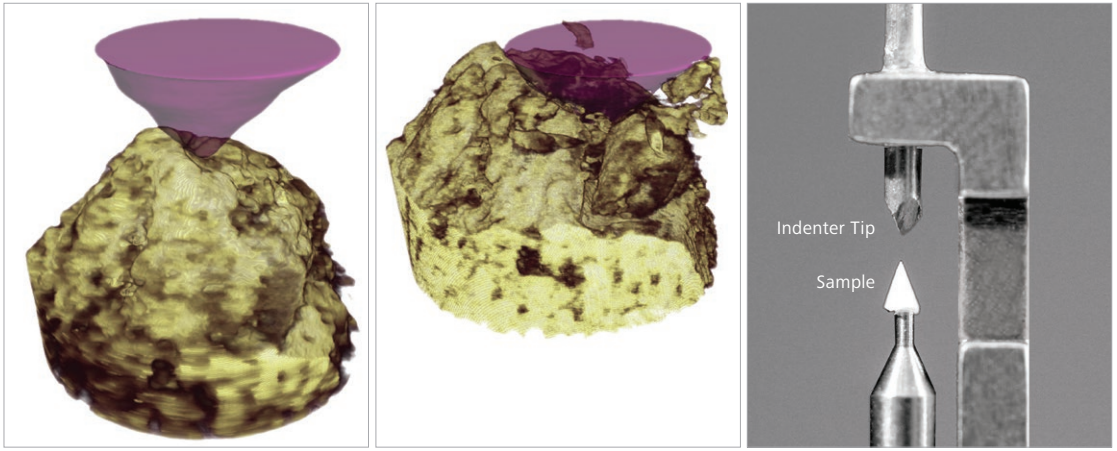
Uncompressed *Compressed* *Decompressed*

Key Specifications

Xradia Ultra Load Stage	LS108 and LS190
Displacement control	450 µm range*
	10 nm resolution*
	Closed loop displacement control
Force measurement	LS108: 0.8 N maximum force* LS190: 9 N maximum force*
	0.1% (full scale) sensitivity
Rotation range	±70 degrees

* Per OEM vendor specifications

Application example: crack propagation and fracture in dentin



Unfractured *Fractured* *Sample mounted in Xradia Ultra Load Stage for indentation.*

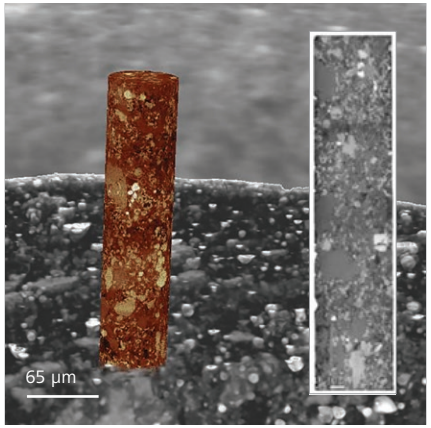
Data courtesy of The University of Manchester

Precisely Tailored to Your Applications

	Task	Xradia 800 Ultra offers
Materials Research	Study and predict material properties and evolution Measure and identify porosity, cracks, phase distribution etc.	Non-destructive, high resolution 4D and *in situ* capabilities
Natural Resources	Perform virtual core analysis to reduce time to results	Nanoscale pore structure measurements for geological samples can now be conducted in a few hours compared to traditional core analysis
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
Electronics	Optimize your package development process	Nanoscale visualization of semiconductor samples for electronics packaging research and development

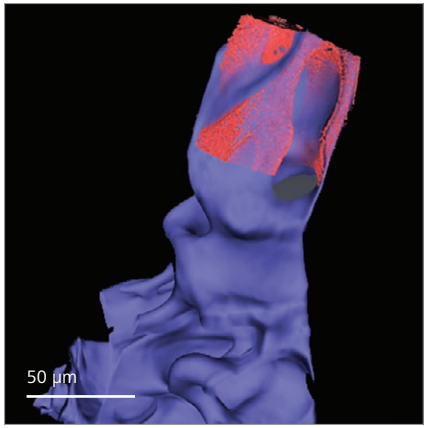
ZEISS Xradia Ultra at Work

Natural Resources



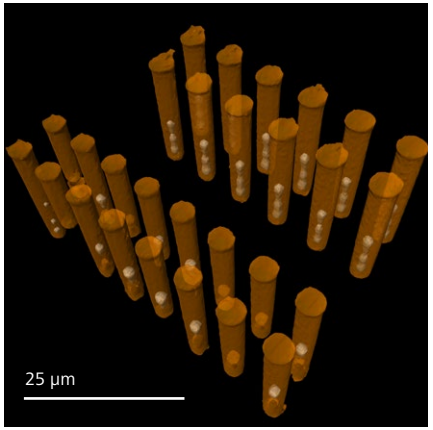
Multi-scale 3D imaging of shale rock. Full sample scanned by Xradia Versa at the 1 µm voxel while highlighted pillar was scanned with Xradia Ultra at 64 nm voxels.

Materials Research



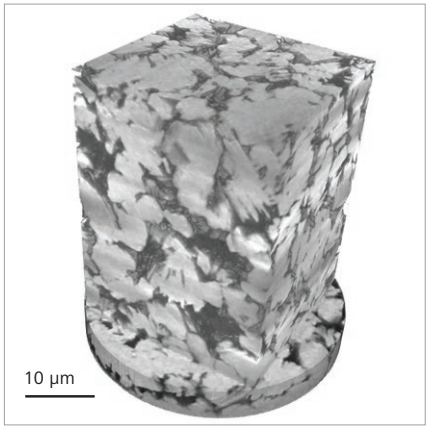
Al-Cu alloy (Xradia Ultra imaged area in red, Xradia Versa in blue).

Electronics R&D



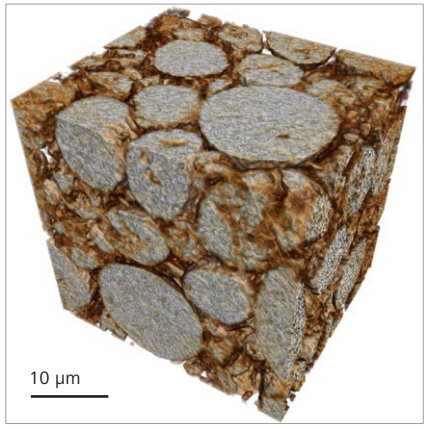
Through Silicon Vias: study intact packages at the nanoscale.

Natural Resources



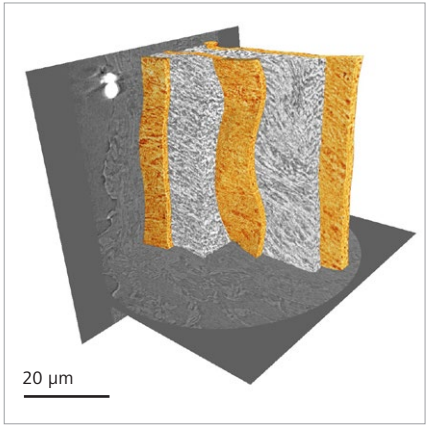
Tight sand for digital rock physics study. Courtesy of iRock Technologies

Energy Materials



Depackaged cathode pore network and voids demonstrated in an off-the-shelf lithium ion battery.

Life Sciences



Elastic lamellae (orange) and interlamellar regions visualized in unstained rat artery wall tissue. Voxel size 64 nm. Courtesy of The University of Manchester

Your Flexible Imaging Solution

1 X-ray Microscope
- ZEISS Xradia 800 Ultra
- 50 nm spatial resolution for synchrotron-quality imaging in the laboratory

2 X-ray Source
- High brightness
- 8.0 keV energy

3 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
- Acquisition: Scout-and-Scan Control System
- 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
- ORS Visual SI for 3D visualization and analysis (optional)

Technical Specifications

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
Absorption Contrast	Standard	Standard
Phase contrast	Optional	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
Radiation Safety	< 1 µS/hr (equivalent to 0.10 mRem/hr)	< 1 µS/hr (equivalent to 0.10 mRem/hr)

Sample Stage	Xradia 810 Ultra	Xradia 800 Ultra
Travel (x, y, z)	6, 8, 6 mm	12, 8, 12 mm
Rotation	>±90°	>±90°
Load capacity	1 kg	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	■	■
Scout-and-Scan Control System	■	■
Comprehensive software suite for data acquisition, reconstruction and visualization	■	■

* Sufficient room temperature and sample stability required

Specifications are subject to change. Please consult ZEISS for current specifications.

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 Protect Service Agreement lets you budget for operating costs, all the while reducing costly downtime and achieving the best results through the improved performance of your system. Choose from service agreements 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.

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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 exploration becomes discovery.
This is the moment we work for.

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