Nanoscale X-ray Imaging: Explore at the Speed of Science

ZEISS Xradia Ultra Family

ZEISS

Seeing beyond

Nanoscale X-ray Imaging: Explore at the Speed of Science

With ZEISS Xradia Ultra you benefit from nanoscale imaging, superior contrast and lab accessibility.

Accelerate your research with synchrotron-quality 3D X-ray nanotomography. Put the ZEISS Xradia Ultra 800-family of X-ray microscopes (XRMs) to work in your lab and unleash the power of the most advanced models in the laboratory-based portfolio of ZEISS XRMs. Now you observe materials phenomena in their native environments, using *in situ* experiments enabled by unique non-destructive nanoscale imaging at resolutions down to 50 nm. Image hard and soft materials alongside each other with both absorption and Zernike phase contrast imaging modes. Your demanding research deserves nothing less than the best image quality and system reliability: Xradia Ultra architecture uses advanced X-ray optics technology adapted from the synchrotron.

Both Xradia 810 Ultra and Xradia 800 Ultra are geared towards optimum image quality for your most frequently-used applications. Which version is best for you depends on the material type for which you want optimal contrast, throughput and material penetration.

In materials research, life sciences, natural resources and other diverse industrial applications, nanoscale 3D X-ray imaging will set the limits of exploration.

Nanoscale Imaging. Superior Contrast. Lab Accessibility.

Supercharge Your Research with Non-destructive Nanoscale Imaging

Harness the power of unique non-destructive imaging to observe nanoscale phenomena in their native environments and perform sub-surface imaging of interior features. Benefit from the only instrument that fills the gap between XRMs with a micrometer-scaled or sub-micron resolution (such as ZEISS Xradia Versa) and higher resolution, but destructive 3D imaging e.g., FIB-SEMs.

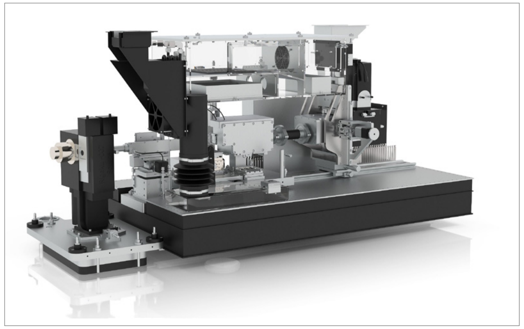
Xradia Ultra uses integrated *in situ* solutions to deliver leading non-destructive 3D X-ray imaging to your laboratory, with resolution down to 50 nm. Add these critical, non-destructive imaging capabilities to your analytical portfolio and you'll be set for breakthrough research.

For Superior Contrast and Image Quality

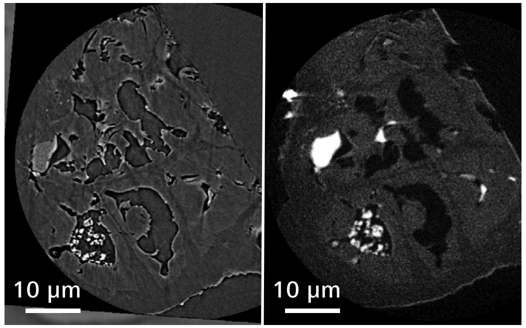
Observe microstructures and nanoscale defects in 3D without destroying your sample. There's no risk of data being altered by slicing artifacts either. Expose details with highest image quality and contrast using absorption and Zernike phase contrast—even in challenging mixed-density samples like composites. Combine both and reveal insights that single contrast imaging could never achieve. Decide which model is right for you based on your most frequently-used applications: the model 810 is perfect for high contrast and throughput imaging, but if it's material penetration you need, then the 800 is the one for you. Both give you the benefit of nanoscale X-ray imaging with synchrotron-like capabilities for unique insights.

Extend the Boundaries of Your Lab

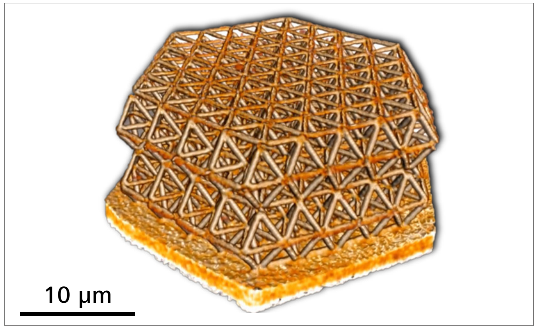
The synchrotron-adapted optics of Xradia Ultra provide a new level of understanding in science and industry labs. This not only removes barriers to access at synchrotron facilities, but also lets you obtain equivalent nanoscale 3D insights on your schedule in your own lab. Perform 4D and *in situ* studies of internal structures never before possible with lab-based imaging methods. Carry out *in situ* mechanical, thermal, electrochemical and environmental testing. Use correlative, multi-scale workflows and connect to other modalities (e.g., ZEISS Xradia Versa and ZEISS Crossbeam, analytics). Serve a broad range of core imaging facility users with a streamlined user interface, including a dedicated Python API.



ZEISS Xradia Ultra optics have a synchrotron pedigree that lets you benefit from nanoscale imaging, superior contrast and lab accessibility.



2D reconstructed slice of a pine needle in Zernike phase contrast (ZPC) mode (left) and absorption contrast (right).



3D printed nanolattice structure, imaged in Zernike phase contrast before in situ *compression experiments. Sample courtesy: R. Schweiger, KIT, DE.*

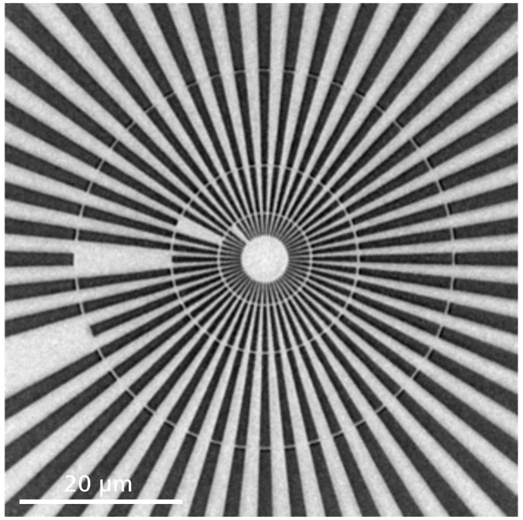
Your Insight into the Technology Behind It

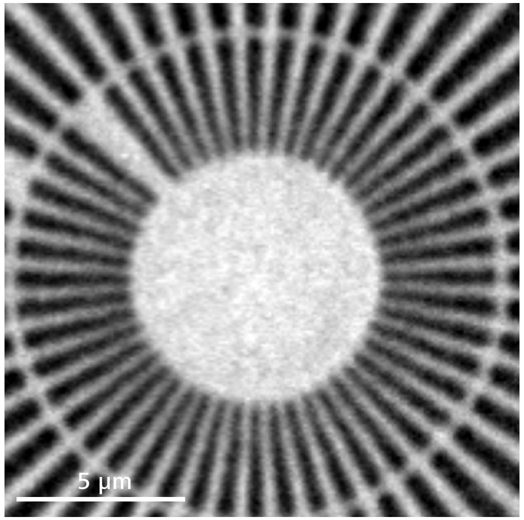
Resolve Nanoscale Features Using X-rays in a Unique Set-up

Unique among laboratory-based microscopes, Xradia 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 that could realize this potential was hindered by the limited brightness of laboratory X-ray sources and the difficulty of fabricating suitably efficient X-ray optics.

Xradia 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) or under varying sample conditions (*in situ*).





Resolution target: 50 nm lines and spaces, left: overview, right: detail view of center.

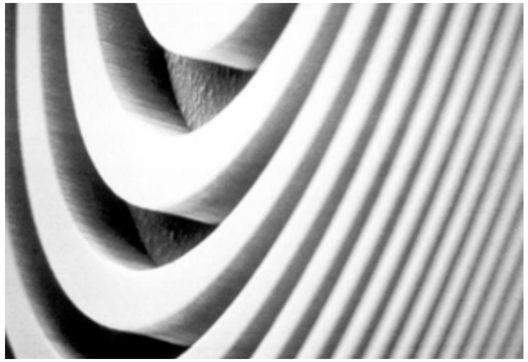
Your Insight into the Technology Behind It

Consider the Advantages of Synchrotron-like X-ray Optics

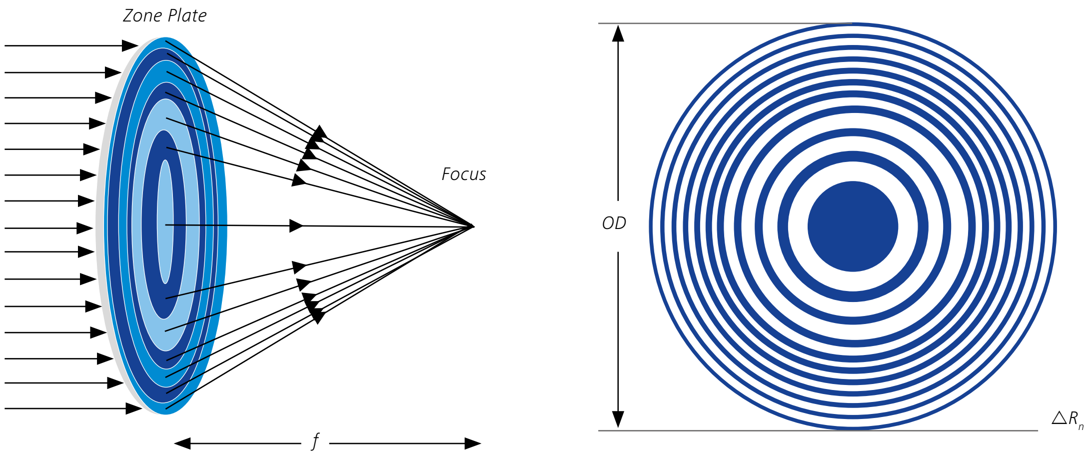
Traditional light or electron optics schemes are not suitable for X-rays because refraction is extremely weak and X-rays are not deflected in magnetic fields. Instead, Xradia Ultra employs proprietary X-ray optics originally developed at synchrotron facilities and optimized by ZEISS for a wide variety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

Discover the full benefits of synchrotron-adapted architecture by using:

- reflective capillary condensers, precision-fabricated to match the source properties and imaging optics at maximum flux density
- Fresnel zone plates, and circular diffraction gratings to use as objective lenses; patented nanofabrication techniques provide the highest resolution and focusing efficiency optics for your research
- phase rings for Zernike phase contrast to provide enhanced image quality
- high contrast and efficiency detectors based on scintillators, optically coupled to a CCD detector to give you the best signal in your limited experimental time.



Fresnel zone plate, scanning electron micrograph.



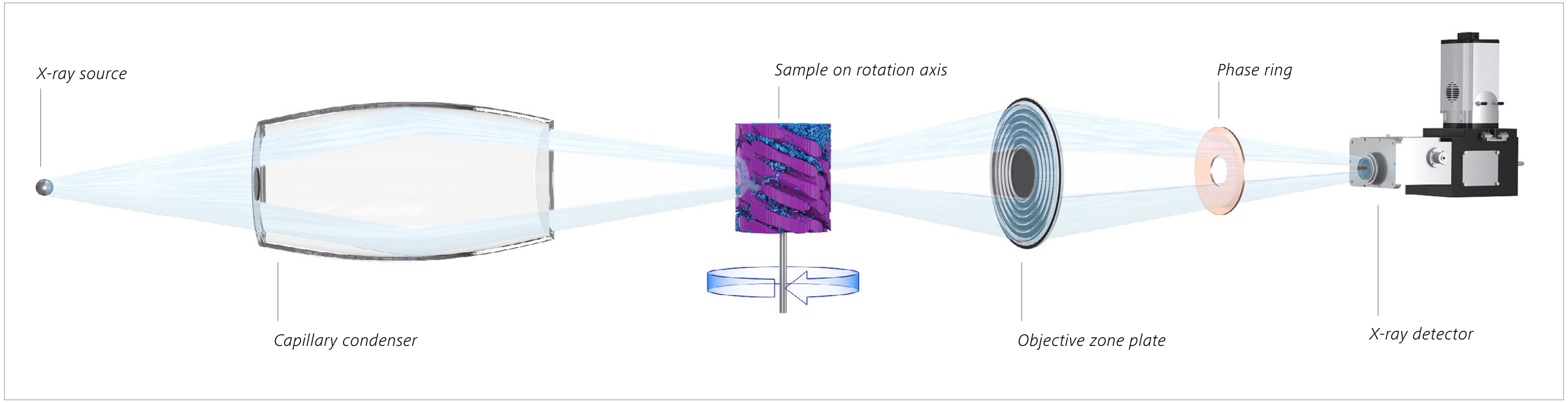
Schematic of a Fresnel zone plate.

Your Insight into the Technology Behind It

How Nanoscale X-ray Imaging is Achieved – Transmission X-ray Microscopy (TXM) Architecture

The architecture of Xradia 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 fine 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.



Beam path illustration of ZEISS Xradia Ultra X-ray microscopes.

Your Insight into the Technology Behind It

ZEISS Xradia 810 or 800 Ultra – Choose the Right X-ray Energy Optimized for Your Applications

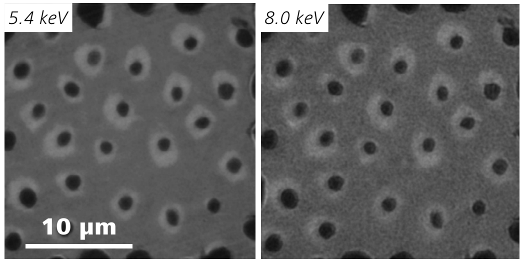
In XRM, contrast depends on the material being imaged and the X-ray energy used. The Xradia Ultra family comprises of Xradia 800 Ultra, operating at 8 keV photon energy, and Xradia 810 Ultra, operating at 5.4 keV. In general, lower energy X-rays are absorbed more strongly and therefore will provide you with higher contrast for most materials. 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 Xradia 800 Ultra delivers higher photon energy for (typically) more transmission. Please, compare the table below for more insight.

Research Topic	Application	ZEISS Xradia 810 Ultra 5.4 keV	ZEISS Xradia 800 Ultra 8.0 keV
Materials Research	Polymers	○	●
	Ceramics	●	●
	Metals	●	○
	Steel	○	●
	Composites	●	●
	SOFC (solid oxide fuel cells)	●	●
	Batteries	●	●
Natural Resources	Carbonate	○	●
	Shale	○	●
Life Sciences	Soft tissue	○	●
	Calcified tissue	○	●
	Bio scaffolds	○	●
Electronics	TSV	●	○

○ *optimal choice for higher throughput and contrast*
● *suitable*

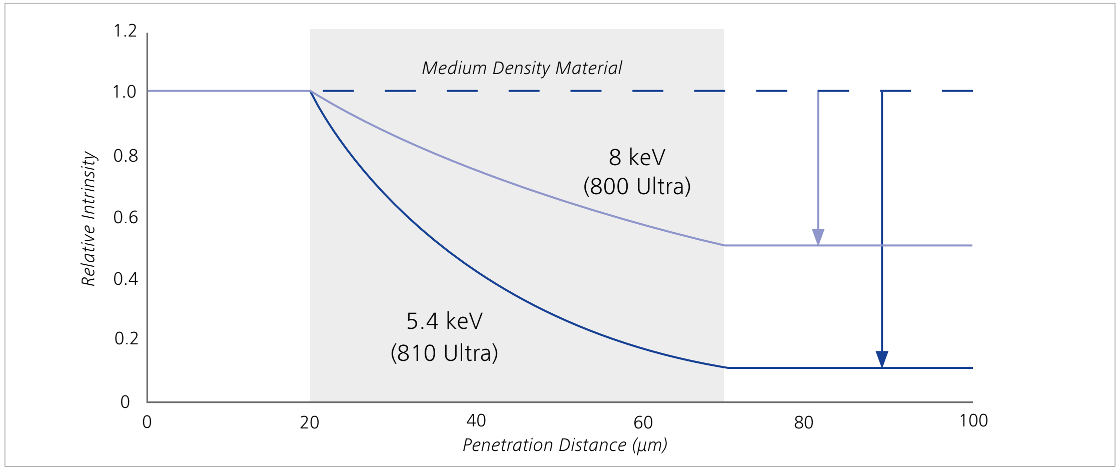
Your Insight into the Technology Behind It

ZEISS Xradia 810 or 800 Ultra – Choose the Right X-ray Energy to Optimize Image Contrast

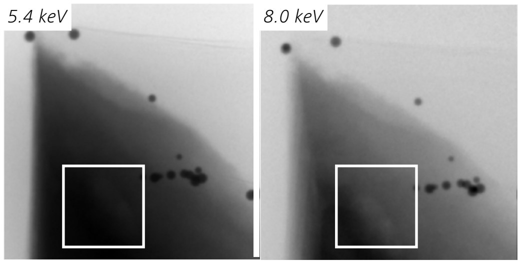


Dentin imaged at 5.4 keV, left, and 8.0 keV, right. At 5.4 keV with Xradia 810 Ultra, acquisition is 10 times faster for equivalent image quality due to optimized contrast.

X-ray Penetration: Medium Density Material

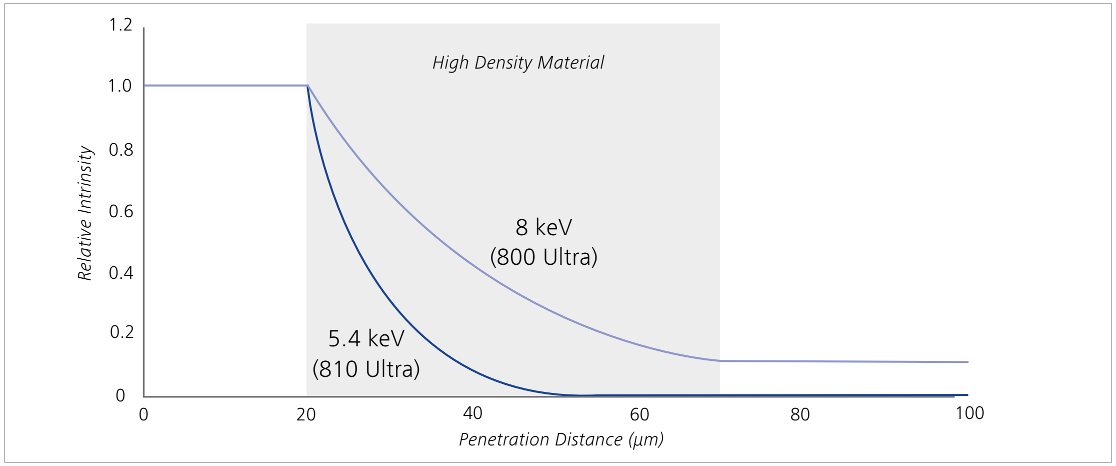


A greater attenuation of X-rays at 5.4 keV (Xradia 810 Ultra) provides superior contrast and higher throughput for low to medium density materials.



Example of a metal sample where the greater penetration of Xradia 800 Ultra 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 (field of view 65 µm).

X-ray Penetration: High Density Material



Greater transmission at 8.0 keV (Xradia 800 Ultra) has higher penetration through dense materials and optimized contrast for high density materials.

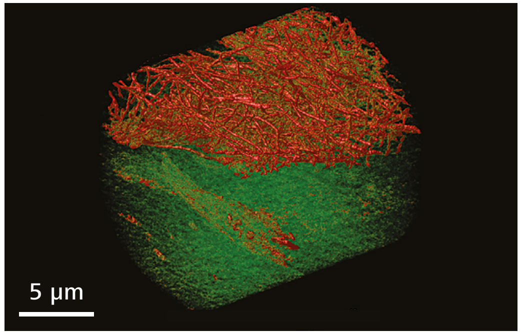
Your Insight into the Technology Behind It

Apply Multiple Contrasts for Diverse Sample Types

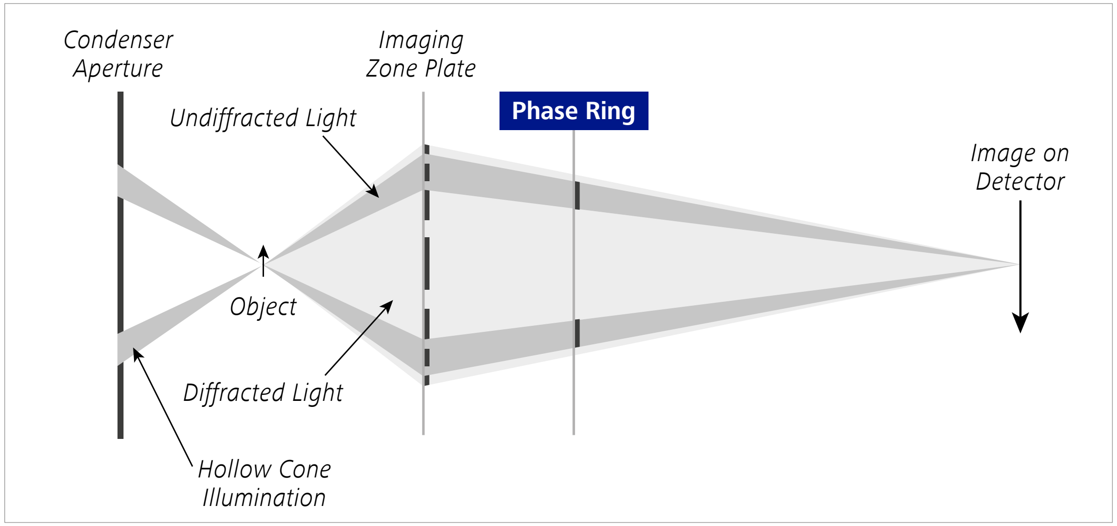
Xradia Ultra offers both absorption and phase contrast imaging to optimize your ability to visualize features of interest in a wide range of samples.

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, leading to 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.



Polymer fibers in a desalination membrane, imaged in phase contrast with Xradia 800 Ultra. Sample courtesy: Industrial Technology Research Institute, Taiwan.

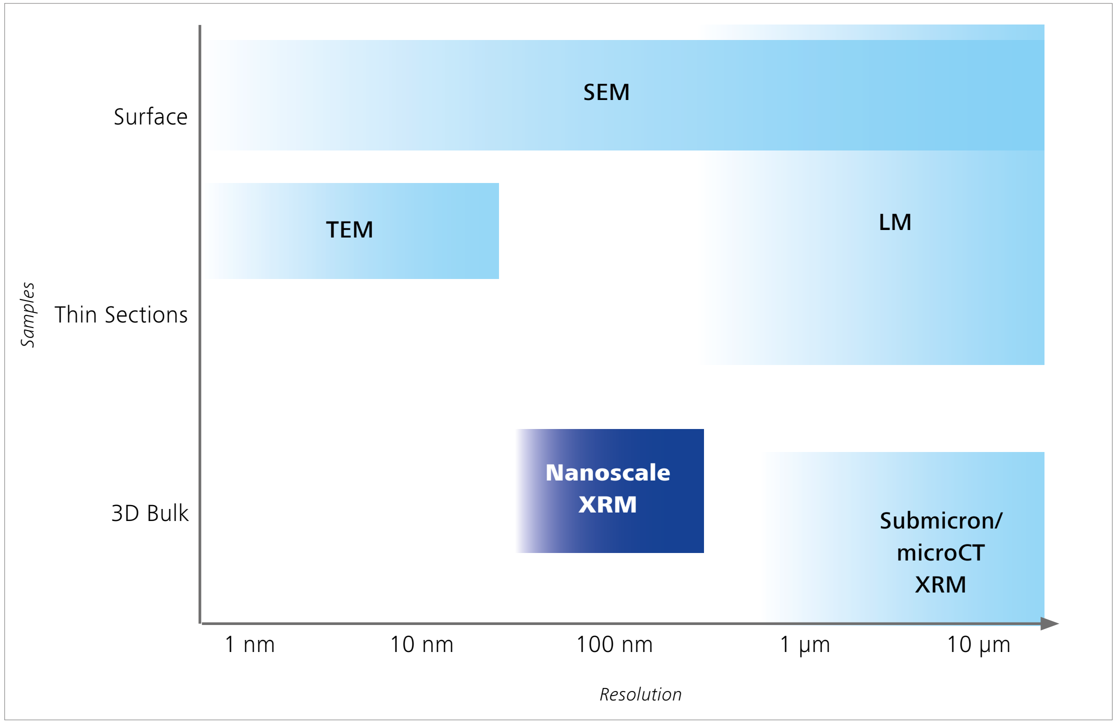


Schematic of optical setup for phase contrast.

Phase ring, scanning electron micrograph.

Your Insight into the Technology Behind It

Bridge the *In Situ* Testing Gap
Todays' materials research deals with properties of materials that emerge under non-ambient conditions or external stimuli. When your goal is to observe microstructural changes occurring under these conditions or stimuli, and to link those changes to the material's performance, *in situ* testing methods and changes in live imaging allow you to do exactly that. Xradia Ultra is uniquely suited to *in situ* experiments and imaging at the nanoscale: it lets you image 3D structures non-destructively in the lab on sample sizes that represent bulk properties but have resolutions corresponding to the nanoscale phenomena.

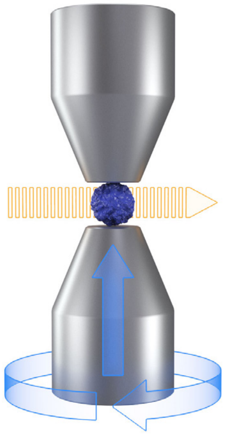


Approximate imaging resolution for in situ *testing, categorized by sample thickness and transparency. ZEISS Xradia Ultra fills in the gap between the nanometer resolution of SEM/TEM (restricted to surface imaging or extremely thin samples) and micrometer-scale tomography.*

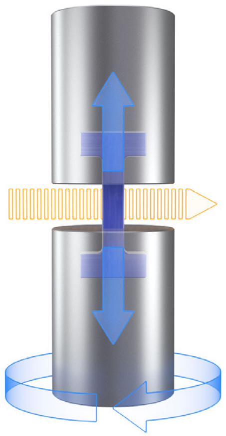
Your Insight into the Technology Behind It

Explore Nanomechanics with *In Situ* Loading Experiments

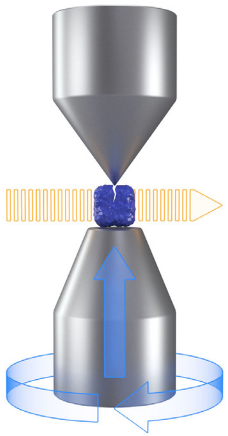
Mechanical properties of materials are intricately linked to their microstructure, especially for highly structured materials like composites, foams, rocks, and biomaterials. ZEISS Xradia Ultra Load Stage takes you deep into a critical new length scale of materials characterization. Use it to observe internal features such as nanoscale cracks and voids that initiate under load. Gain a nanoscale view of material deformation and failure. Then, connect these features with properties observed on the macroscale to guide material development and an understanding of how to prevent failure.



Compression: the sample is "pinched" between the two anvils that move towards each other. Study structural deformation under uniaxial compressive load in this mode.



Tension: the two anvils move away from each other, pulling on the sample. Observe structural deformation under uniaxial tensile load in this mode.

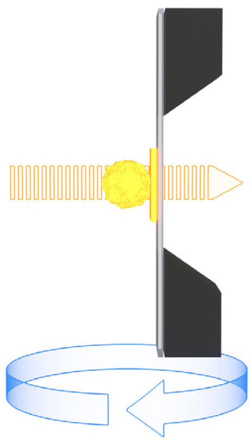


Indentation: a sharp nanoindenter mounted to one of the anvils is pushed into the sample to initiate e.g., cracks. Common types of indenters include cone, cube corner, or wedge.

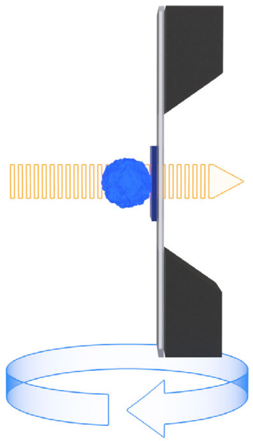
Your Insight into the Technology Behind It

Use *In Situ* Heating Techniques to Understand the Microstructure of Materials

As material properties depend on microstructure, developing novel materials requires a deep understanding of how to control their evolution. In certain applications – say research on metal alloys, catalysis and 3D printing, new parts are formed under heating. Norcada Heating Stage for ZEISS Xradia Ultra allows you to observe microstructural evolution *in situ* at the nanoscale and in 3D. It opens the door to tailoring the finished part. Using this technique you can understand microstructure evolution and material performance better; for example, it lets you see how porosity evolves and can be observed in 3D using the heating stage in Xradia Ultra.



Heating: integrated sample heater raises the local temperature of the sample. Image microstructural changes occuring at elevated temperature such as annealing, melting, and thermal expansion.



Biasing: sample voltage is changed by applying a bias between the sample and holder. Take images of the sample changes that occur at elevated voltages.

Expand Your Possibilities

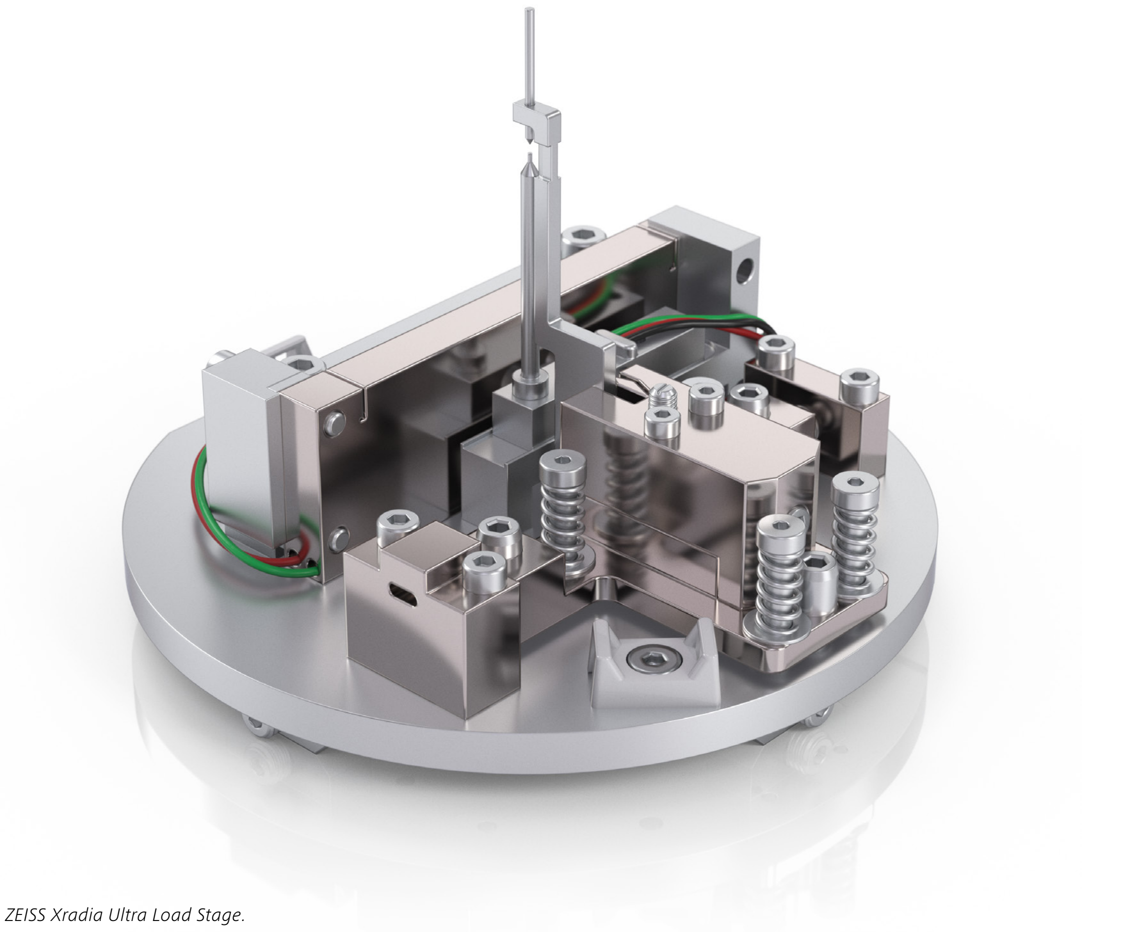
Observe Your Specimens *In Situ* in Their Native Environment
Understand how deformation events and failure relate to local nanoscale features. By complementing existing mechanical testing methods you can gain insights into behavior across multiple length scales.

ZEISS Xradia Ultra Load Stage enables *in situ* nanomechanical testing— compression, tension, indentation—in a unique way, using non-destructive 3D imaging. This lets you study the evolution of interior structures in 3D, under load, down to 50 nm resolution.

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
Applications	High strength alloys, building materials, fibers / composites, biomaterials, coatings, foams

** Per OEM vendor specifications*



ZEISS Xradia Ultra Load Stage.

Expand Your Possibilities

Perform *In Situ* Heating Experiments
Investigate nanoscale material changes such as degradation processes, thermal expansion and phase transitions at elevated temperatures.
The Norcada Heating Stage for ZEISS Xradia Ultra enables non-destructive nanoscale 3D imaging at elevated sample temperatures. MEMS heater technology provides sample heating in air up to 500 °C. Its flexible design allows for sample heating or sample voltage biasing with the same unit.

Key Specifications

Heating Stage	HS500
Temperature Control	RT-500 °C range
	1-5 °C resolution
	Standalone GUI
Biasing Specs per OEM	Max DC Voltage: 350 V
	Max AC Frequency: 50 kHz
	Max Temp Stability: 500 °C
Rotation Range	±65 degrees
Applications	Solder melting and solidification, metal annealing, polymer research, fuel cell processing, catalysts

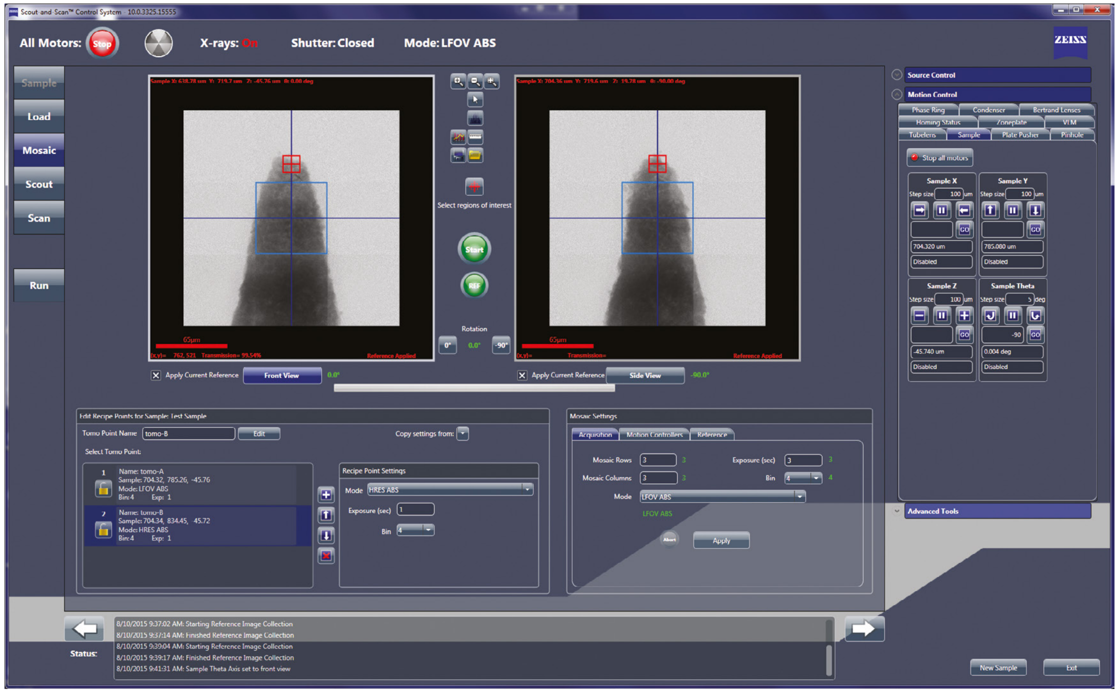
Heating stage is provided by Norcada Inc. Canada Contact your local ZEISS representative for more information.

Norcada Heating Stage for ZEISS Xradia Ultra.

Expand Your Possibilities

Create Efficient Workflows With a User-friendly Software

Boost your productivity with ZEISS’ innovative Scout-and-Scan™ Control System – streamline sample and scan setup. 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. Advanced users gain full control of the microscope for custom imaging tasks or integration into *in situ* experiments using an integrated Python API.



Set. Load. Scout, Scan. Run. It's that simple. Find out how the graphical user interface guides you through the creation of your workflow effortlessly.

Expand Your Possibilities

› In Brief

› **The Advantages**

› The Applications

› The System

› Technology and Details

› Service

Dragonfly Pro – Your Visual Pathway to Quantitative Answers
Dragonfly Pro is an advanced 3D visualization and analysis software from Object Research Systems (ORS). It is offered exclusively by ZEISS for processing XRM, SEM (scanning electron microscope), FIB-SEM (focused ion beam) and Helium ion data. Combining advanced image processing algorithms and state-of-the-art volume rendering, Dragonfly Pro enables high-definition exploration and powerful quantitative analysis of your data. Dragonfly Pro is distinguished by its ease-of-use, best-in-class image segmentation toolkit, and endless extensibility. Import your multi-scale, multi-microscope image studies, and you'll discover that Dragonfly Pro is the most advanced correlative imaging platform available. Integrated with a suite of image processing tools for 2D and 3D image registration, resampling, and more, Dragonfly Pro's cutting-edge image filters will make imaging artifacts disappear.

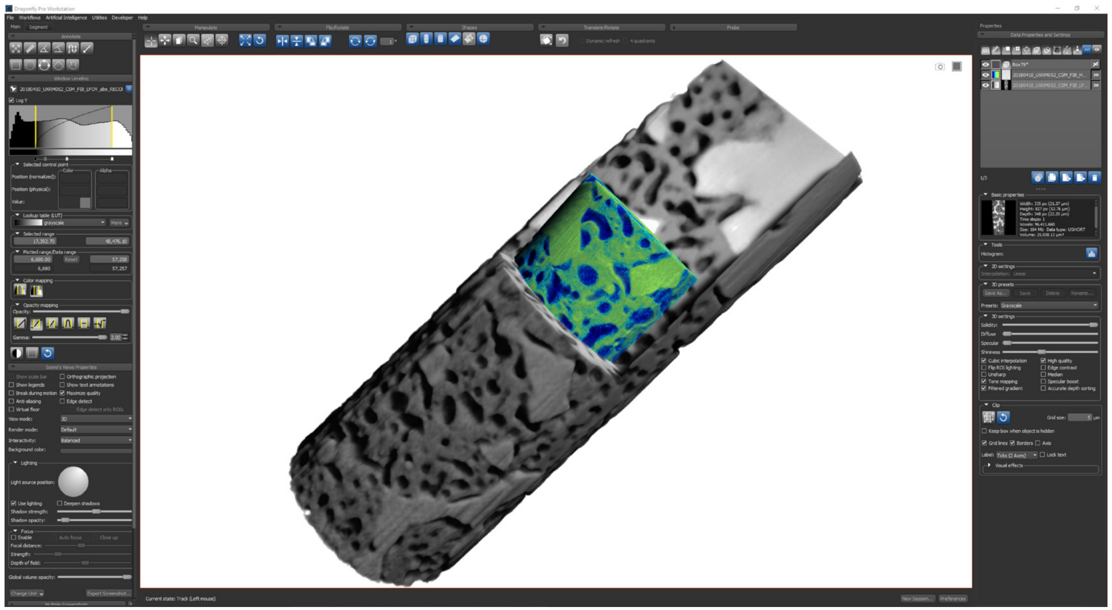
Your visual results will let your images speak for themselves. Capture and share insightful screenshots— as still images or 2D animations—or turn to Dragonfly Pro's 3D Movie Maker for effortless high-impact 3D animations.Dragonfly Pro's intuitive user interface and simple features that map directly onto users' needs make even first-time users highly productive.

The integrated machine learning engine solves segmentation of even the most challenging samples, while interactive painting and contouring tools make curation and fine edits a breeze.

Record your workflows and replay them as needed or in batch. Even write custom Python code to drive the software to highly-customized and robust solutions.

Simple to use while delivering the quantitative insights and visual impressions that you demand; Dragonfly Pro will accelerate your 2D/3D data productivity.

Key User Benefits:
- Ease-of-use
- Image segmentation
- Multi-modal (XRM, SEM, FIB-SEM, Helium ion)
- Scripting robust and batching workflows
- Multi-scale
- Quantitative Analysis
- Movies



Tailor the tools that are optimal to your workflow: choose plug-ins that allow you to control registration, map differences, and customize appearance. Solid Oxide Fuel Cell, imaged on Xradia Ultra. Sample courtesy: Colorado School of Mines, US

Expand Your Possibilities

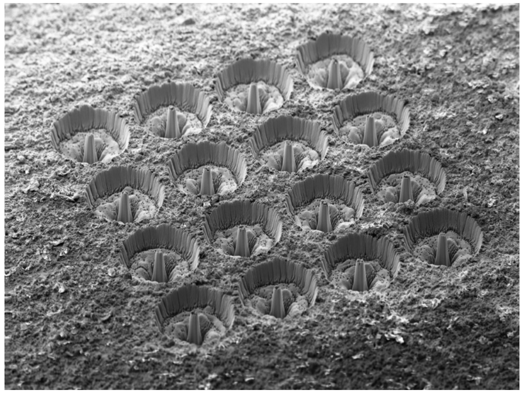
Discover how the LaserFIB Workflow enhances your high-resolution imaging and analysis.

ZEISS Crossbeam laser Recommended Product for Sample Preparation

Rapidly access your regions of interest (ROIs), even if they are deeply buried, or easily produce pillar-shaped samples for tests with ZEISS Xradia Ultra or at the synchrotron.

Use the LaserFIB that combines a ZEISS Crossbeam FIB-SEM with an ultra-short pulsed femtosecond (fs) laser to enable correlative workflows across multiple length scales. Find your ROIs using, e.g., previously acquired 3D X-ray microscopy datasets and target them for further analysis using the Cut-to-ROI workflow.

Use the fs laser to cut through millimeters of material and produce samples for analysis with Xradia Ultra. Then, leverage the FIB-SEM capabilities for nano- and micrometer-scale milling, tomography, imaging, and advanced analytics.



Array of 16 pillars machined using the fs-laser in a titanium alloy FOV 2.1 mm. Crossbeam 350 laser.

ZEISS Xradia Ultra at Work: Energy Materials

- › In Brief
- › The Advantages
- › **The Applications**
- › The System
- › Technology and Details
- › Service

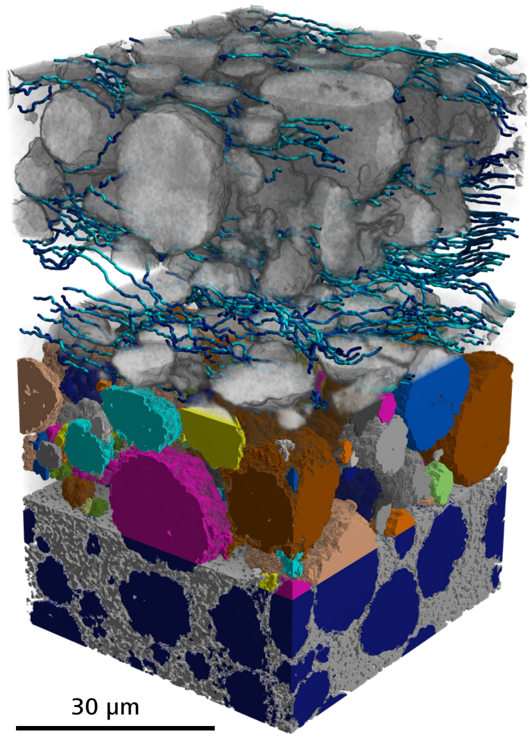
While the future of energy use depends on developing new functional materials and advanced devices such as batteries, solar cells, and fuel cells, how these devices perform is intricately linked to their microstructure and the microstructure of the materials that compose them. These complex material systems rely on the interplay between many different materials to operate effectively.
In research, you must first try to understand the microstructural details in their native environment before you can fully understand how a device will perform. From there you can begin to build effective models to explain processes and develop the next generation of materials that will underpin energy research in years to come.

Typical Tasks and Applications

- Microstructure and device evaluation
- Defect analysis
- Phase distribution
- Pore and fracture quantification

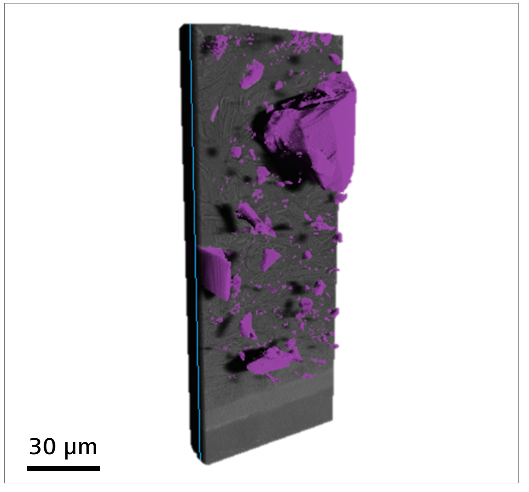
How You Benefit from ZEISS Xradia Ultra

- Analyze hard and soft materials and mixtures (e.g. battery electrodes or fuel cell layers) with absorption and Zernike phase contrast.
- Observe materials in their native environment with optional *in situ* capabilities.
- Non-destructive imaging provides critical insights to correlative workflows involving e.g. sub-micron XRM or FIB-SEM.

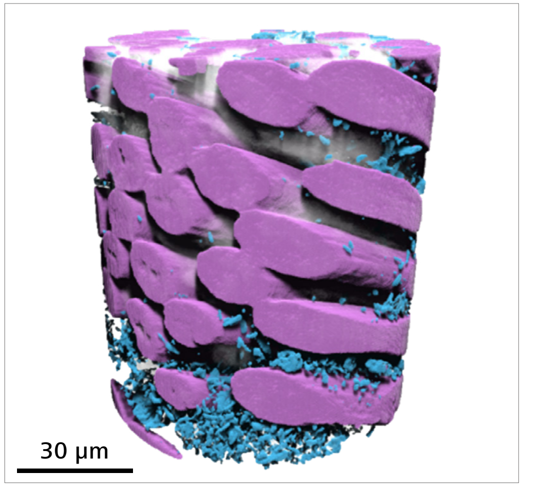


Lithium ion battery cathode pore network and simulated diffusion through carbon binder domain. Imaged with Xradia 810 Ultra.

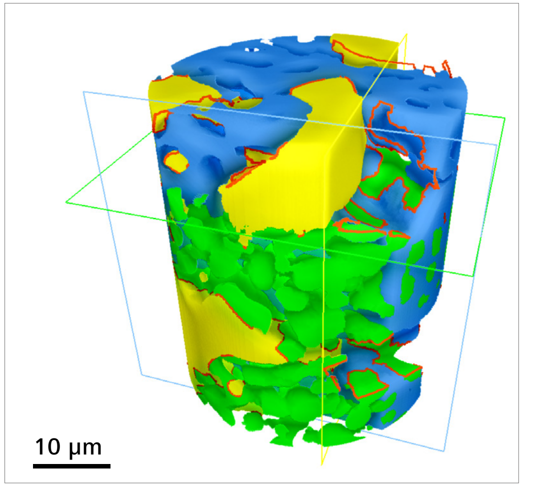
ZEISS Xradia Ultra at Work: Energy Materials



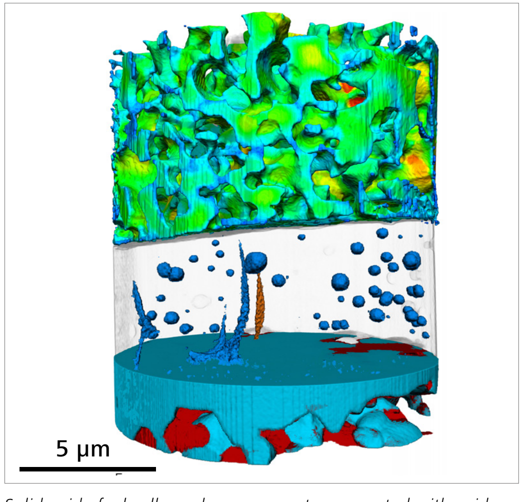
Graphite anode with silicon particles segmented through full thickness (copper layer seen on bottom). Imaged with Xradia 810 Ultra.



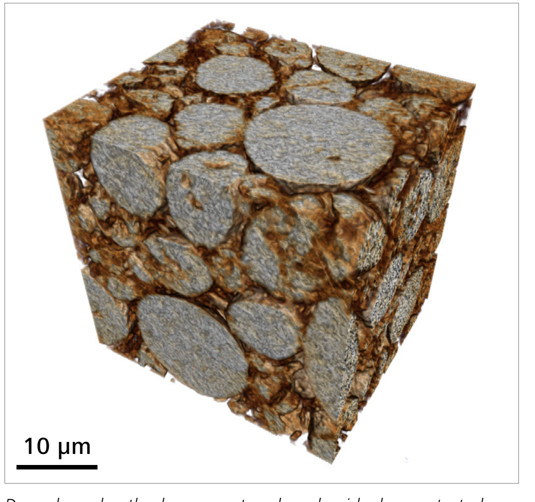
Carbon gas diffusion layer fibers and microporous layer material from polymer electrolyte fuel cell. Imaged with Xradia 810 Ultra.



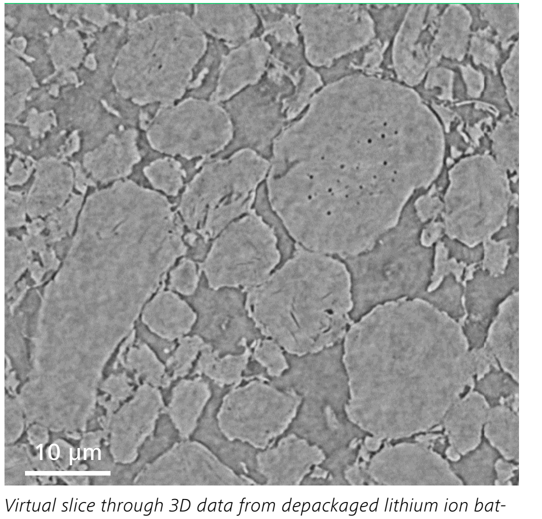
Solid oxide fuel cell segmented anode components and triple point boundary. Imaged with Xradia 810 Ultra.



Solid oxide fuel cell anode components segmented with voids seen in center electrolyte. Imaged with Xradia 810 Ultra.



Depackaged cathode pore network and voids demonstrated in an off-the-shelf lithium ion battery. Imaged with Xradia 800 Ultra.



Virtual slice through 3D data from depackaged lithium ion battery graphite anode material. Imaged with Xradia 810 Ultra in Zernike phase contrast.

ZEISS Xradia Ultra at Work: Polymer and Soft Materials

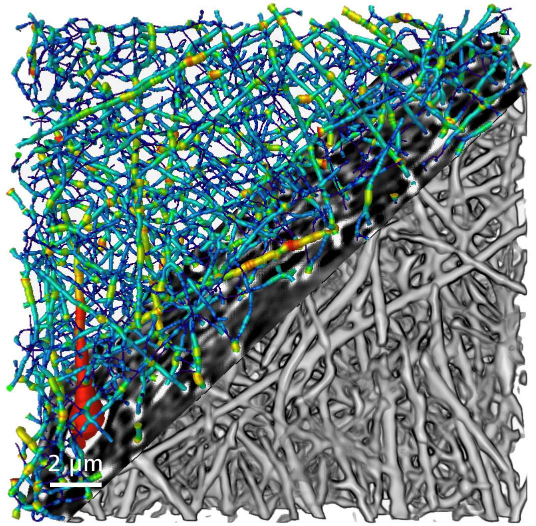
Whether you are designing novel materials, optimizing processes or discovering new surface properties of bio-materials, bio-inspired materials, or polymers, it is essential to have 3D microstructural characterizations of these materials in high resolution. However, often these samples are challenging to image because of their low contrast, highly porous nature, and sensitivity.

Typical Tasks and Applications

- Structural analysis, segmentation and quantification
- Pore network characterization
- Correlative multiscale characterization due to typical hierarchical structure of some bio-materials
- Failure analysis and process control

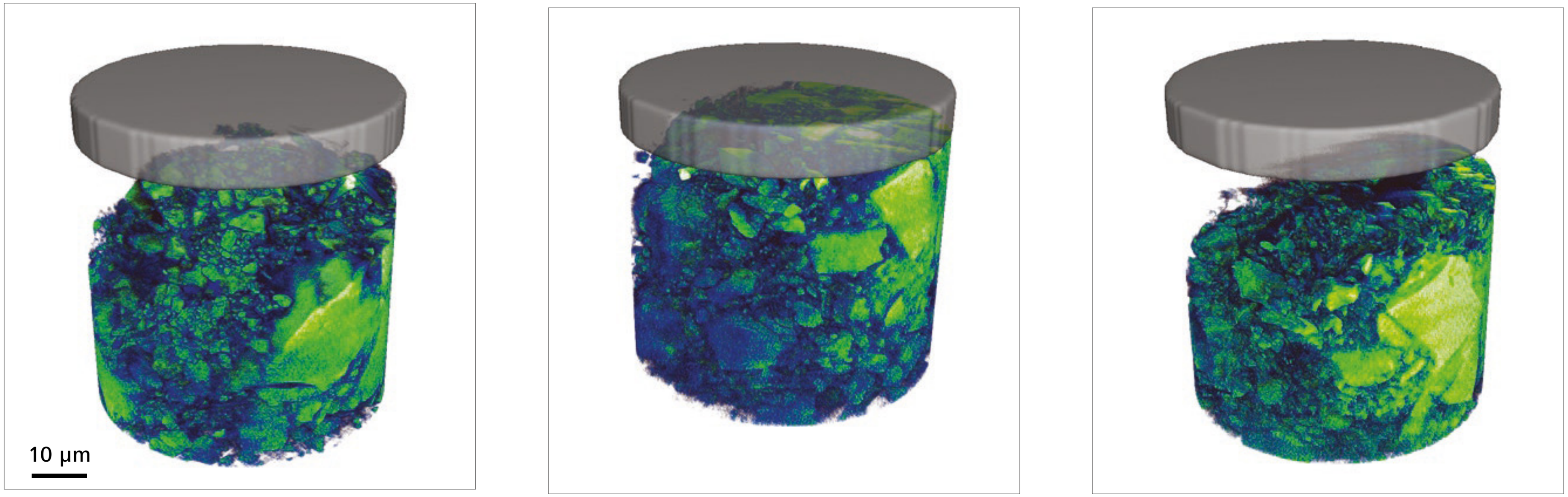
How You Benefit from ZEISS Xradia Ultra

- Image non-conducting and porous samples using charge-free X-ray beam.
- Avoid artifacts due to material sectioning techniques using non-destructive nanoscale X-ray imaging.
- Measure soft, low contrast materials and their interface to harder materials using absorption and Zernike phase contrast.
- Non-destructive imaging provides critical insights to correlative workflows involving e.g. sub-micron XRM or FIB-SEM.

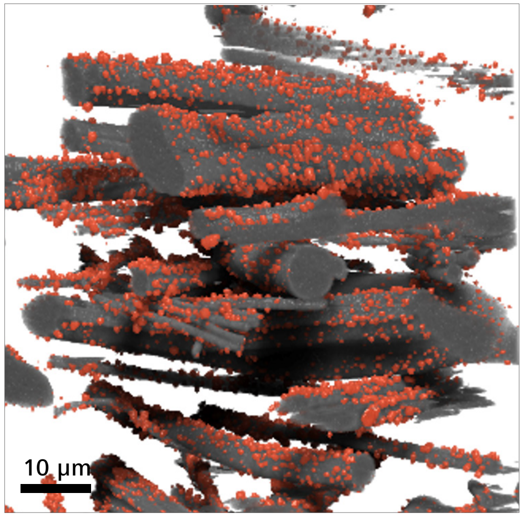


Cross-linked gelatin nanofibrous scaffold. Imaged with Xradia 810 Ultra

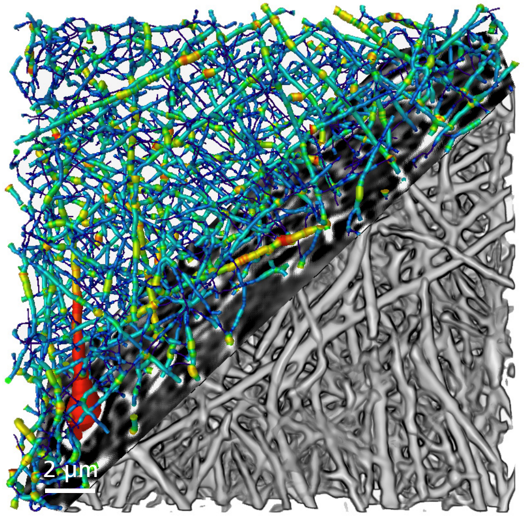
ZEISS Xradia Ultra at Work: Polymer and Soft Materials



Elastomer at different stages of compression during an in situ *load stage experiment (left: uncompressed, middle: compressed, right: after compression). Imaged with Xradia 810 Ultra (scale bar applicable on all three images).*



Polymer mask fibers with segmented NaCl particles to quantify filtering effectiveness. Imaged with Xradia 810 Ultra.



Cross-linked gelatin nanofibrous scaffold. Imaged with Xradia 810 Ultra.

ZEISS Xradia Ultra at Work: Engineering Materials

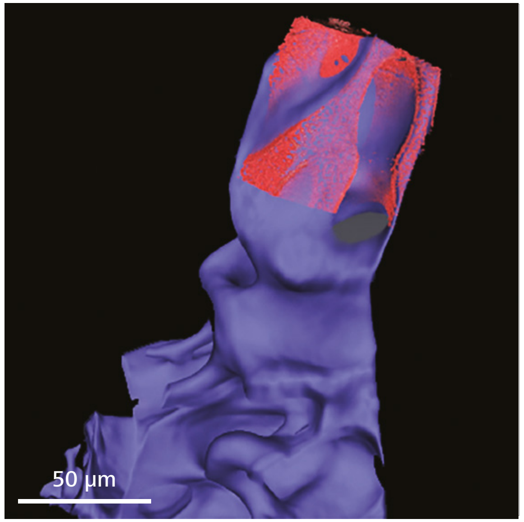
The rapid pace of technological innovation is driving the need for materials with exceptional properties such as high strength-to-weight ratio, structural and dimensional stability at higher service temperatures, extreme mechanical loading, and operating conditions including extended lifetimes. Among these are advanced alloys that are resistant to heat, fracture and fatigue as well as high strength-to-weight ratio composite structures, environmentally-durable and self-healing concrete, and reliable, robust protective coatings—all that, and then there are the innovations in the processes that make these materials possible. That's quite a list and, increasingly, the properties of these novel materials are intricately linked to their carefully engineered microstructures. Designing the next generation of advanced engineering materials will hinge on a deep understanding of these microstructures and how they relate to the resultant properties.

Typical Tasks and Applications

- Microstructure and inclusion distribution analysis
- Characterizing *in situ* material behavior under varying conditions
- Generating representative 3D image data to capture all the significant microstructural characteristics for input into simulation models
- Understanding how corrosion and microstructural defects evolve under exposure to service environments

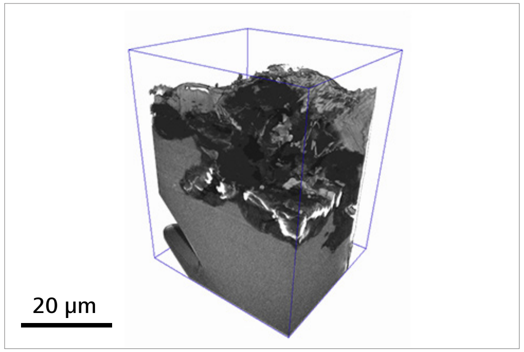
How You Benefit from ZEISS Xradia Ultra

- Produce 3D nanoscale characterization of engineering materials such as metals and catalysts using two unique contrast modes – absorption and Zernike phase contrast.
- Observe materials in their native environment with optional *in situ* capabilities.
- Non-destructive imaging provides critical insights into correlative workflows involving e.g. submicron XRM or FIB-SEM.
- Track microstructural evolution in 3D with non-destructive nanoscale 3D imaging.

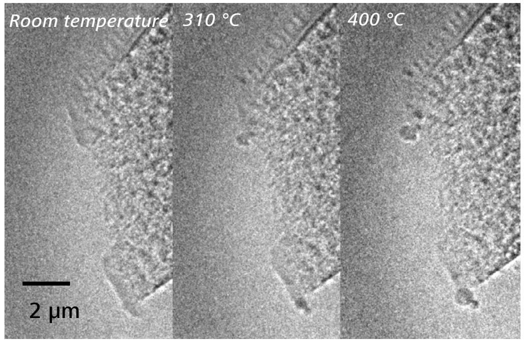


Al-Cu alloy (Xradia 800 Ultra imaged area in red, Xradia Versa in blue).

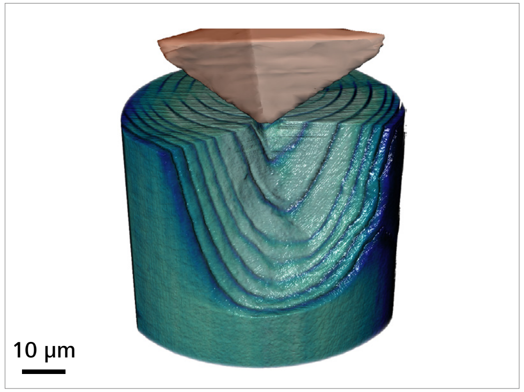
ZEISS Xradia Ultra at Work: Engineering Materials



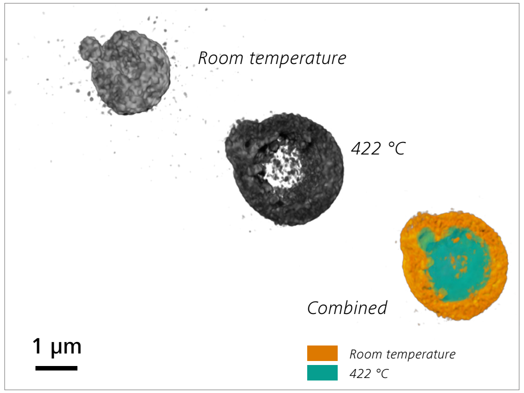
Magnesium-alloy corrosion. Imaged with Xradia 810 Ultra.



Supported liquid metal catalyst sample imaged at sequentially elevated temperatures to monitor redistribution of liquid metal phases. Sample: courtesy of University of Erlangen – Nuremberg, DE. Imaged on ZEISS Xradia 810 Ultra with Norcada Heating Stage.



In situ *compressive indentation failure in a SiC:BN composite fiber. Imaged with Xradia 810 Ultra and Ultra Load Stage.*



Zinc particle undergoing oxidation at elevated temperature in situ *using the Norcada Heating Stage. Imaged with ZEISS Xradia 810 Ultra.*

ZEISS Xradia Ultra at Work: Life Sciences

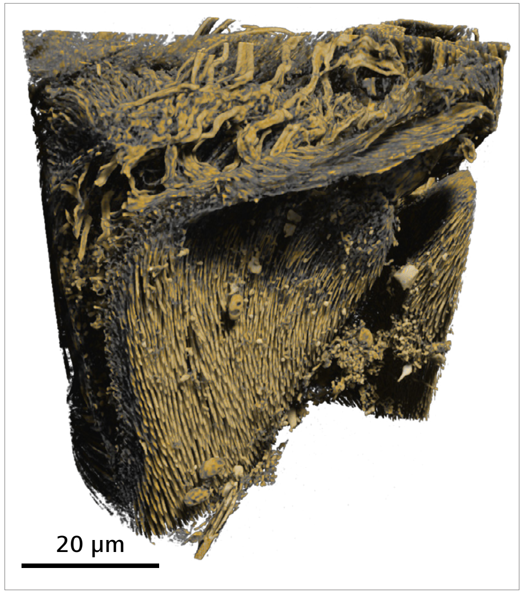
From zoology and plant sciences to developmental biology, neuroscience, cell biology and general ultrastructural investigation—as varied as the branches of life sciences are, microscopy is your common and essential tool. And whether you are characterizing biological samples in detail, uncovering cellular or subcellular processes or exploring the nanostructure of your sample, X-ray microscopy lets you image these phenomena non-destructively, in 3D and often without needing complex sample preparation.

Typical Tasks and Applications

- Characterization of micro- and nano-structures in unique zoological samples
- 3D visualization of the complex ultrastructure of cells, tissues and organisms etc.
- Exploring localization and accumulation of nanoparticles in biological specimens
- Visualizing cell-cell and cell-scaffold interactions in bioscaffolds
- Non-destructive imaging of large areas to identify regions of interest (ROIs) for correlative electron microscopy

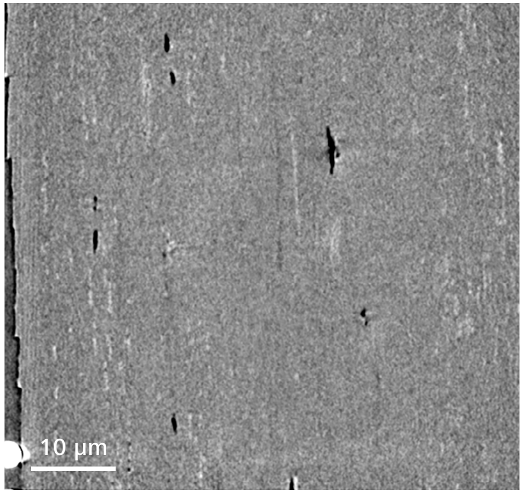
How You Benefit from ZEISS Xradia Ultra

- Use Zernike phase contrast to image low-Z specimens natively, without the need for staining.
- Combine the contrast modes Zernike and absorption for dual contrast imaging and easily segment all components of your sample, using Dragonfly Pro.
- Add a critical step to your correlative imaging workflow with non-destructive nanoscale imaging and significantly improve your thin specimen preparation yield for e.g. TEM.

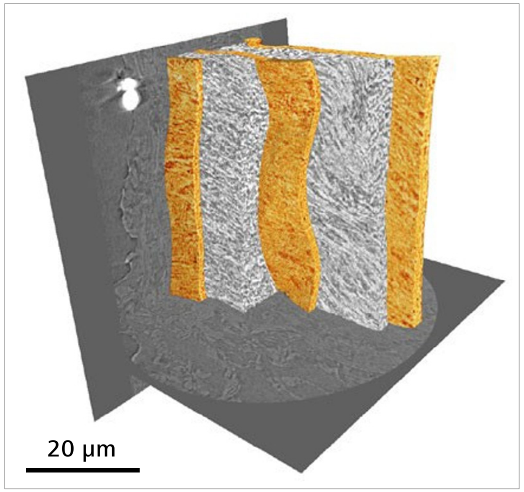


Suction cup musculature and pillae from dipteran fly Hapalothrix lugubris. *Imaged with Xradia 810 Ultra.*

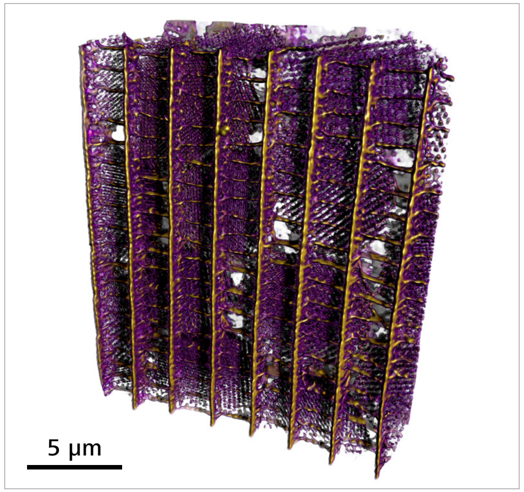
ZEISS Xradia Ultra at Work: Life Sciences



Human hair virtual cross-sectional image with pores (black), and pigment melanosomes (white) visible within the interior. Exterior cuticle layers visible at left. Imaged with Xradia 810 Ultra in Zernike phase contrast.



Elastic lamellae (orange) and interlamellar regions visualized in unstained rat artery wall tissue. Imaged with Xradia 800 Ultra. Image courtesy: The University of Manchester, UK.



Gyroid nanostructured butterfly wing. Imaged with Xradia 810 Ultra.

ZEISS Xradia Ultra at Work: Electronics

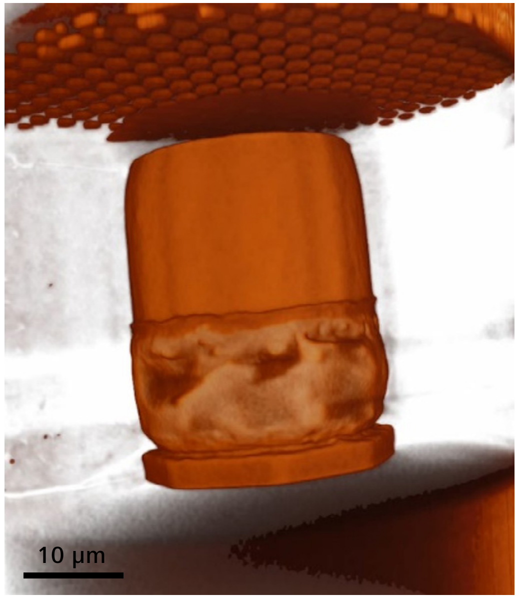
As transistor and interconnect sizes approach the hard limits set by physics, material complexity increases and 3D architectures such as FinFET and Gate-all-around transistors are becoming increasingly common. This brings many new challenges to semiconductor process control, quality control and quality assurance. Non-destructive 3D X-ray microscopy allows you to image at resolution without sacrificing the contextual information of these complex devices.

Typical Tasks and Applications

- Visualization of 3D back end of line (BEOL) interconnects for sample integrity and defect detection
- *In situ* imaging and thermal characterization of 3D integrated circuits (ICs)
- Large area imaging of thinned planar regions of interest for defect inspection

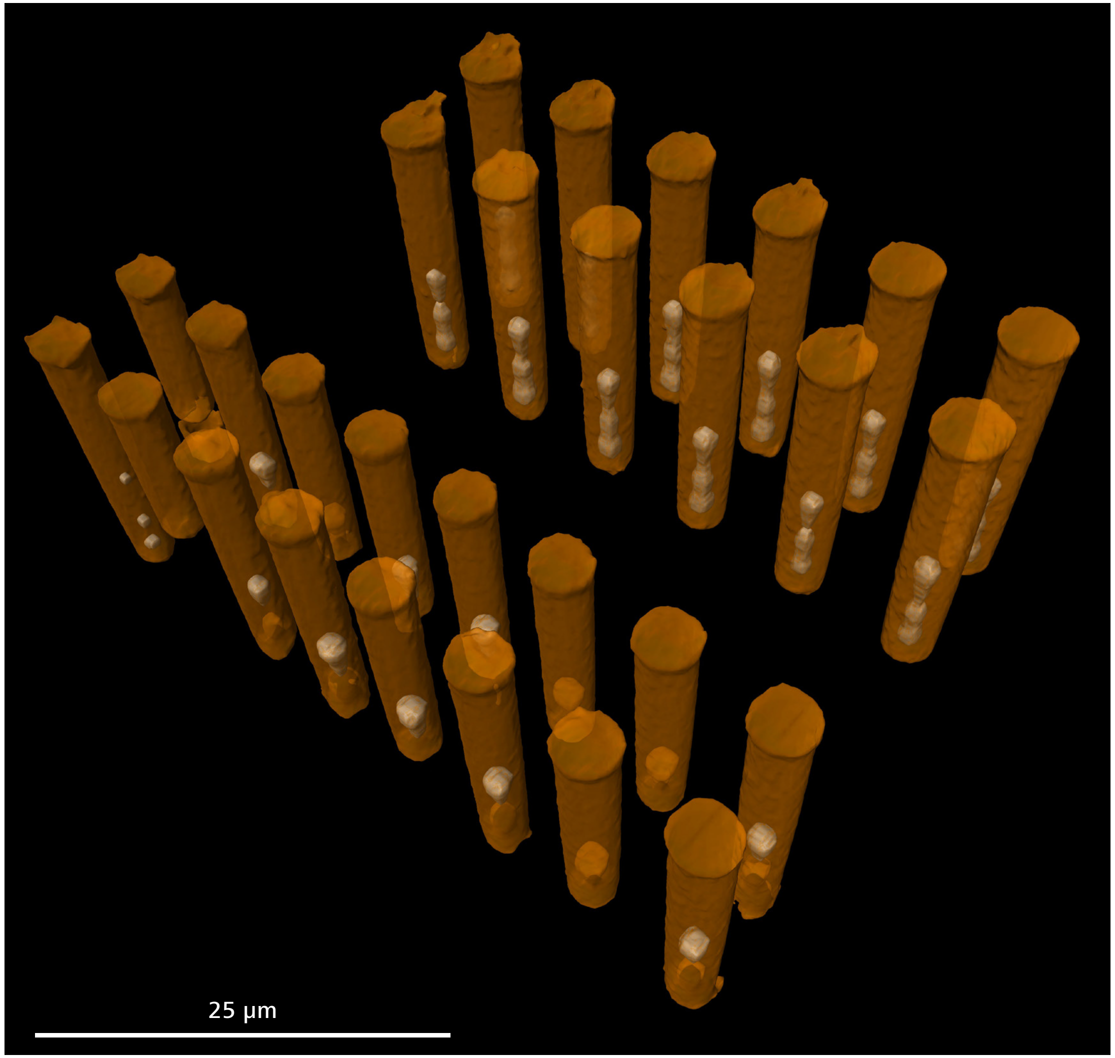
How You Benefit from ZEISS Xradia Ultra

- With a resolution corresponding to a feature size 100 nm pitch, Xradia Ultra allows you to image non-destructively down in low layers of your device.
- You can introduce seamless nanoscale non-destructive 3D imaging into your existing correlative workflow with e.g. submicron CT and EM.

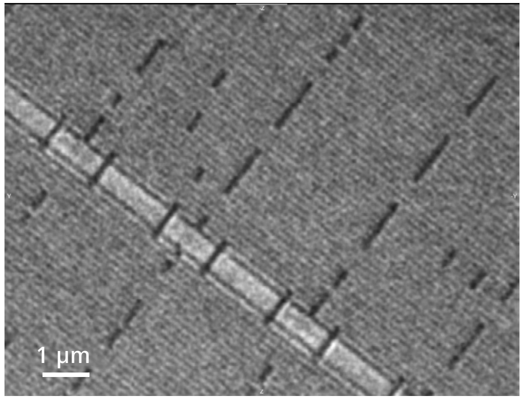


Copper microbump and interconnect visualization and defect inspection. Imaged with Xradia 800 Ultra.

ZEISS Xradia Ultra at Work: Electronics



TSV (Through Silicon Vias) study of intact packages at the nanoscale. Imaged with Xradia 800 Ultra.

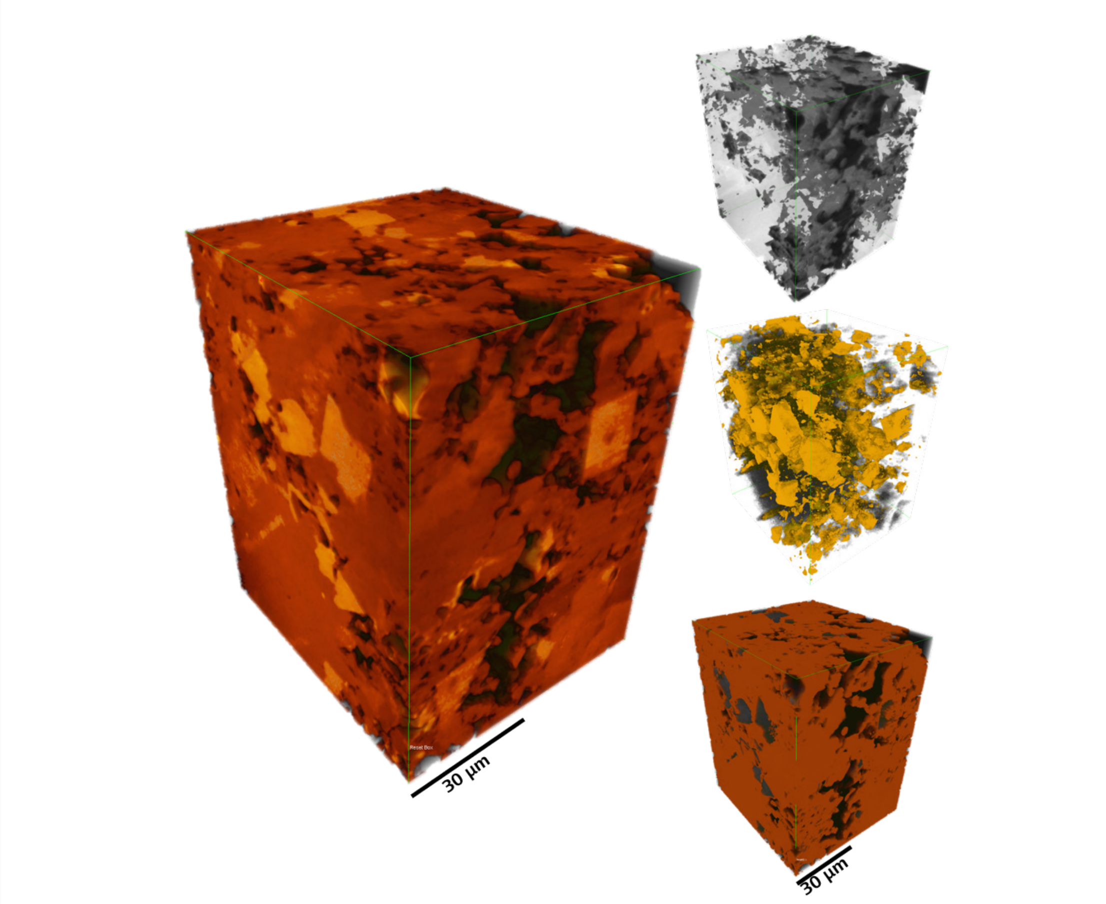


10 nm process microprocessor metal layer. Imaged with Xradia 800 Ultra.

ZEISS Xradia Ultra at Work: Geosciences

› In Brief
› The Advantages
› **The Applications**
› The System
› Technology and Details
› Service

In petrochemical extraction from unconventional (say, shale) reservoirs, it takes accurate geological understanding to assess the productivity potential and determine the most economical and environmentally-prudent extraction methodology. Given the rich geochemistry and microstructure of these environments, microscopy plays a critical role in generating reliable assessments and aiding in the development of new practices at both the scale and speed required by industry.



Segmentation of shale rock into component phases imaged with Xradia 810 Ultra

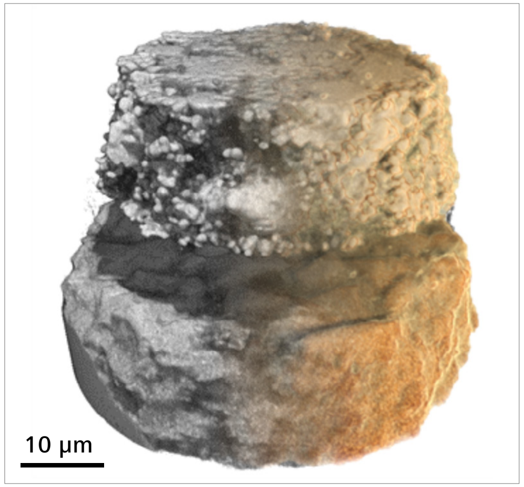
Typical Tasks and Applications

- Identification of component materials and phase distribution in a matrixed geological sample
- Multi-scale 3D pore network visualization and fluid flow modelling in a porous sample
- Determining mechanical, thermal and flow properties of geologic materials

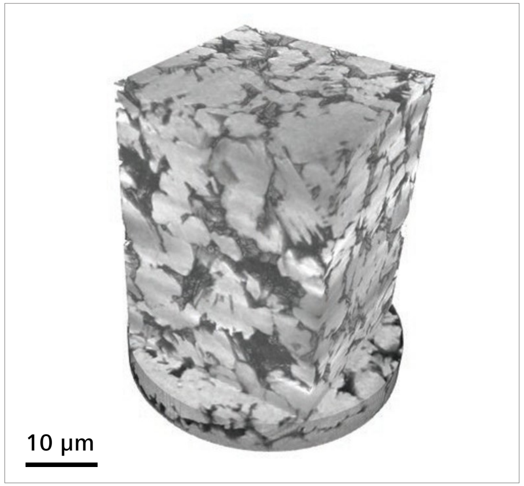
How You Benefit from ZEISS Xradia Ultra

- Dual absorption and Zernike phase contrast imaging lets you detect and segment different components of varying density.
- Use nanoscale 3D data to perform accurate fluid flow modelling without sacrificing pore resolution.
- Submicron porosity measurements enable a seamless correlative imaging workflow using traditional CT imaging.
- Leverage non-destructive 3D nanotomography with dedicated *in situ* solutions to image samples under non-ambient conditions.

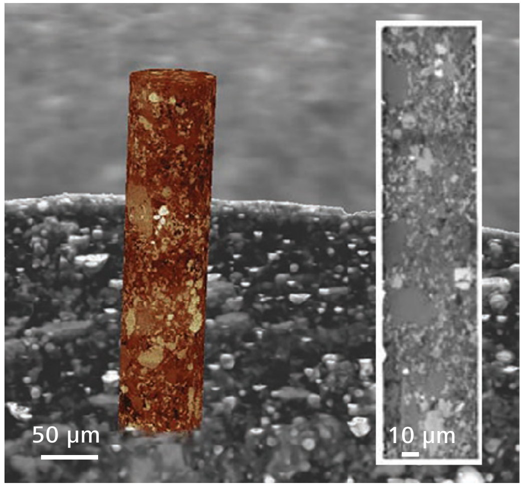
ZEISS Xradia Ultra at Work: Geosciences



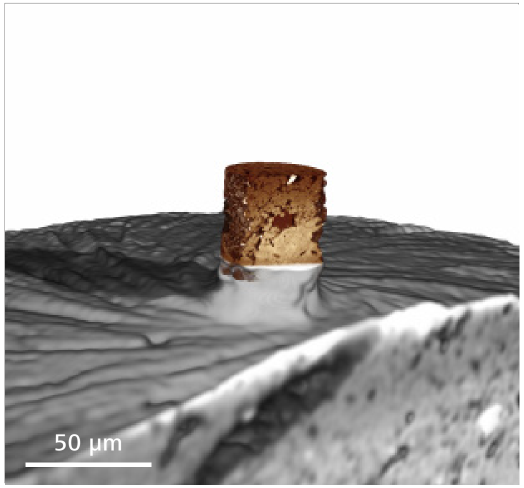
Micropillar of micritic carbonate microporosity, extracted using a multiscale workflow from petrographic thin section. Imaged with Xradia 810 Ultra.



Tight sand for digital rock physics study. Image: courtesy of iRock Technologies. Imaged with Xradia 810 Ultra.

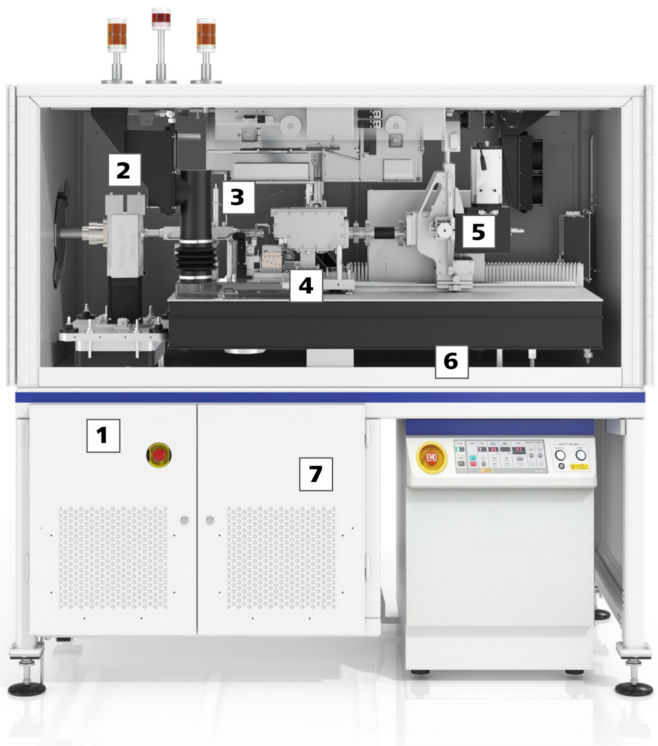


Multi-scale 3D imaging of shale rock. Full sample scanned by Xradia Versa at 1 µm voxel size while highlighted pillar was scanned with Xradia 810 Ultra at 64 nm voxels.



Shale sample imaged with Xradia 810 Ultra.

Your Flexible Choice of Components



1 X-ray Microscope
- ZEISS Xradia 800 Ultra and ZEISS Xradia 810 Ultra
- 50 nm spatial resolution for synchrotron-quality imaging in the laboratory

2 X-ray Source
- ZEISS Xradia 810 Ultra with chromium source [5.4 keV]
- ZEISS Xradia 800 Ultra with copper source [8 keV]

3 *In situ* Modules
- ZEISS Xradia Ultra Load Stage Norcada Heating Stage for ZEISS Xradia Ultra

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

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

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)

7 Workstation & Software
- Powerful workstation with GPU-based reconstruction
- Acquisition: Scout-and-Scan Control System
- XMReconstructor for tomographic reconstruction
- XM3DViewer for 3D visualization
- Compatible with a wide range of 3D viewers and analysis programs

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	800×	200×
Absorption Contrast	Standard	Standard
Phase contrast	Optional	Optional

X-ray Source	ZEISS Xradia 810 Ultra	ZEISS 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		
Travel (x, y, z)	6, 8, 6 mm	12, 8, 12 mm
Rotation	> ± 90°	> ± 90°
Load capacity	1 kg	1 kg
Features		
Automated image alignment for tomographic reconstruction*	HRES and LFOV modes	HRES and LFOV modes
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*

● *included*

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

› In Brief
› The Advantages
› The Applications
› The System
› Technology and Details
› **Service**

ZEISS Service – Your Partner at All Times

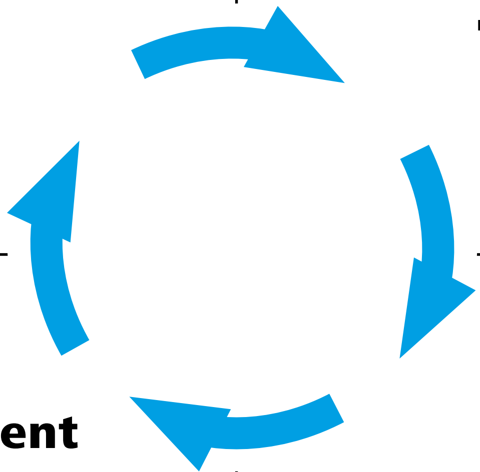
Your microscope system from ZEISS is one of your most important tools. For over 170 years, the ZEISS brand and our experience have stood for reliable equipment with a long life in the field of microscopy. You can count on superior service and support - before and after installation. Our skilled ZEISS service team makes sure that your microscope is always ready for use.

Procurement

- Lab Planning & Construction Site Management
- Site Inspection & Environmental Analysis
- GMP-Qualification IQ/OQ
- Installation & Handover
- IT Integration Support
- Startup Training

Operation

- Predictive Service Remote Monitoring
- Inspection & Preventive Maintenance
- Software Maintenance Agreements
- Operation & Application Training
- Expert Phone & Remote Support
- Protect Service Agreements
- Metrological Calibration
- Instrument Relocation
- Consumables
- Repairs



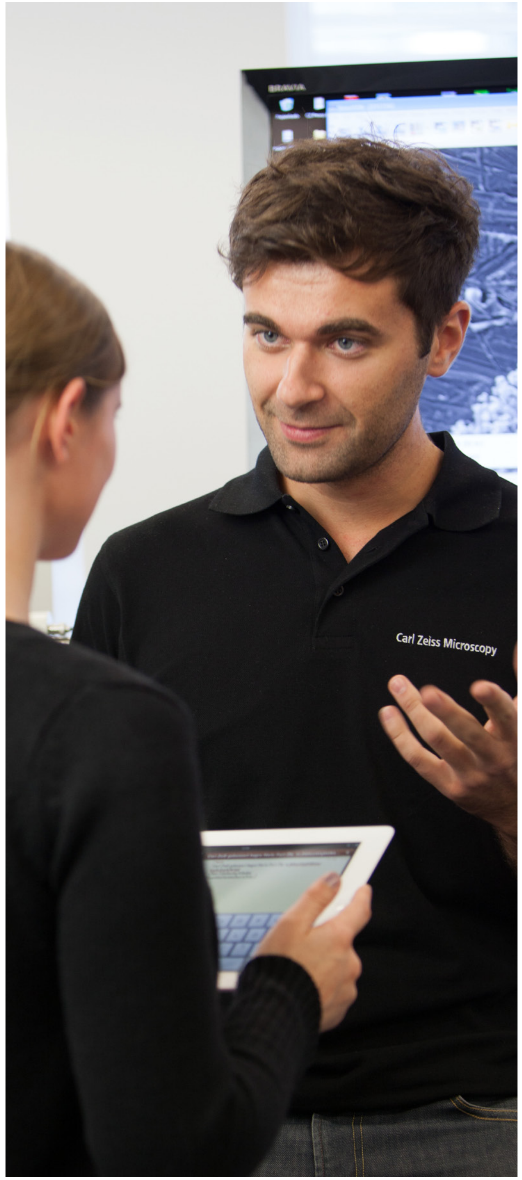
New Investment

- Decommissioning
- Trade In

Retrofit

- Customized Engineering
- Upgrades & Modernization
- Customized Workflows via APEER

Please note: Availability of services depends on product line and location



>> **www.zeiss.com/microservice**

Carl Zeiss Microscopy GmbH
07745 Jena, Germany
microscopy@zeiss.com
www.zeiss.com/xradia-ultra