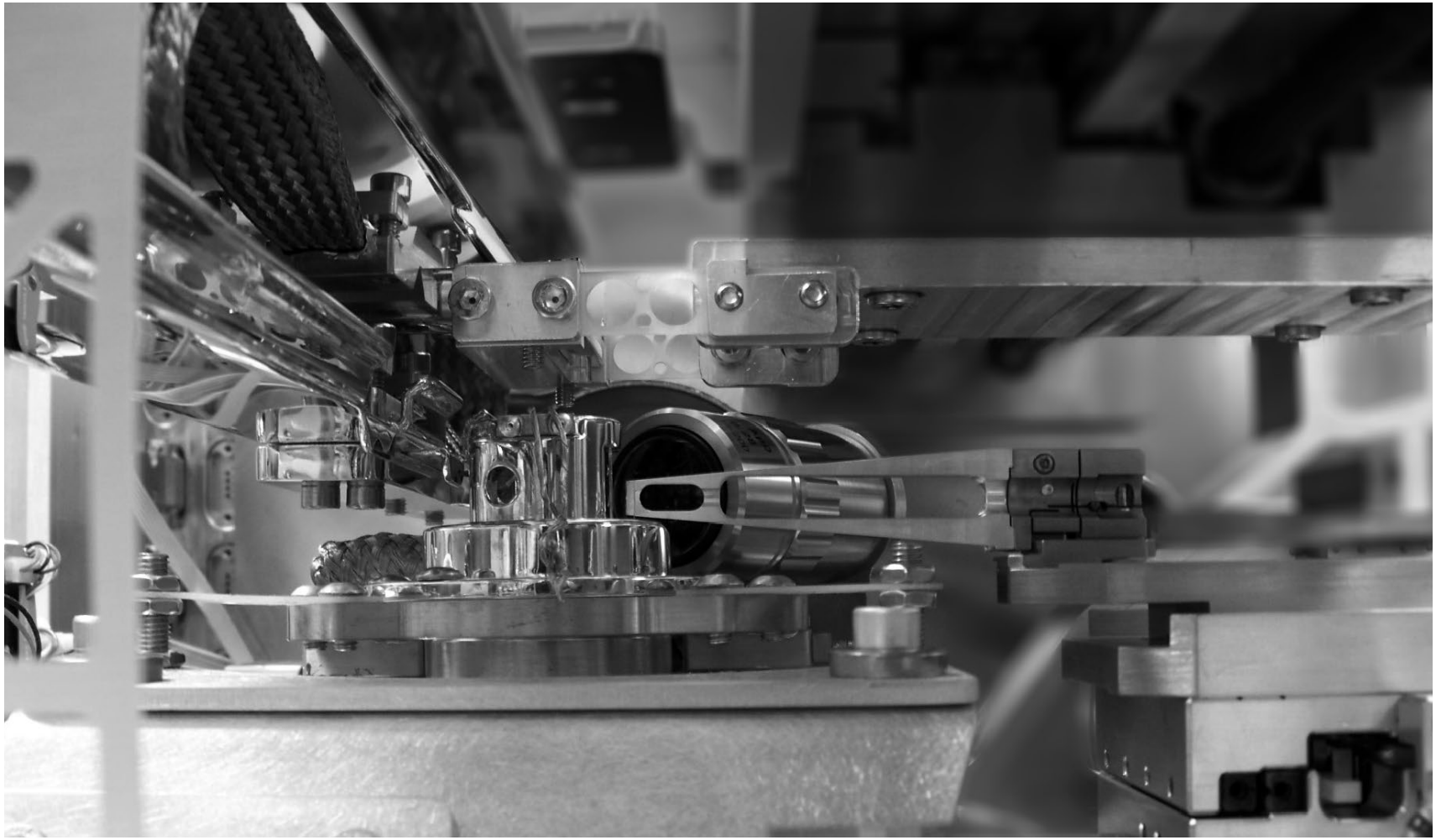

Product Information
Version 2.0

ZEISS Xradia Synchrotron Family

Nanoscale X-ray Microscopy for Synchrotrons

We make it visible.

Achieve energy-tunable ultra-high resolution 3D imaging at your synchrotron

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

ZEISS Xradia Synchrotron solutions bring nanoscale X-ray imaging to your synchrotron facility, enabling you to forgo costly and time consuming in-house development. Proprietary X-ray optics and a proven 3D X-ray microscopy platform leverage the ultra-bright, tunable X-ray beams available at modern synchrotron facilities. Achieve fast non-destructive 3D imaging with resolution down to 30 nm with a variety of contrast modes. The Xradia Synchrotron family includes 3D imaging microscopes covering a wide energy range from soft to hard X-rays.

ZEISS Xradia Synchrotron Family: Tomography. *In Situ*. Cryo.

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Xradia 800 Synchrotron:
Hard X-ray Nanotomography

3D tomographic imaging with X-rays provides detailed volumetric data of internal structures without the need for cutting or sectioning at the region of interest. Operating in the 5-11 keV energy range, Xradia 800 Synchrotron images a wide range of samples including battery and fuel cell electrodes, catalysts, and soft and hard tissue with resolution down to 30 nm. Xradia 800 Synchrotron is ideally suited for advanced techniques such as XANES spectro-microscopy for 3D chemical mapping and *in situ* imaging to enable you to study materials under real operating conditions.

Xradia 825 Synchrotron:
Soft X-ray Nanotomography

3D tomographic imaging in the soft X-ray range, including the water window up to about 2.5 keV, is ideally suited for structural imaging of whole cells and tissue. Cryogenic sample handling enables you to image in a frozen hydrated state, minimizing effects of radiation damage while maintaining the sample as close to its natural state as possible. Further applications include chemical state mapping of both organic and inorganic materials and imaging of magnetic domains.

Advanced Imaging in 4D and beyond:
***In situ, in operando,* spectroscopy**

ZEISS synchrotron solutions are ideally suited for advanced techniques beyond structural imaging. Leveraging the bright and tunable X-ray beams available at 2nd and 3rd generation synchrotron facilities, you can combine imaging with XANES spectroscopy to map the elemental and chemical composition of your specimen in 3D, or study nanostructural evolution *in situ* under real operating conditions. For example, observe batteries *in operando* during the charge-discharge cycle to monitor the cracking of particles or changes to the oxidation state of the electrode materials. Monitor chemical reactions in a gas or fluid flow reactor. Measure the change in porosity of solid oxide fuel cell electrodes under thermal cycling. Or, quantify the relative distribution of different chemical phases under high pressure using a diamond-anvil-cell.

Transmission X-ray Microscopy (TXM) Architecture

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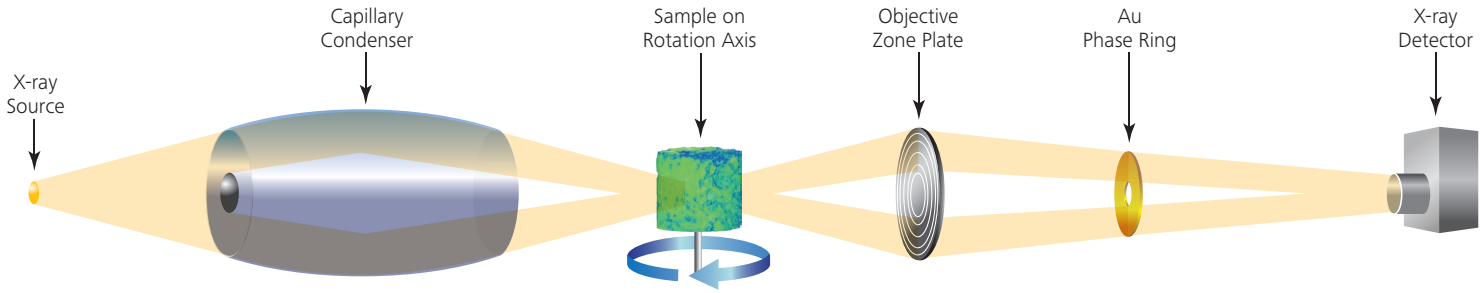
The architecture of Xradia 800/825 Synchrotron (also known as Full-Field or Imaging Microscope architecture) is conceptually equivalent to that of an optical microscope or transmission electron microscope (TEM):

- The specimen is illuminated by the monochromatized synchrotron beam using a high-efficiency capillary condenser
- A Fresnel zone plate objective forms a magnified image of the sample on 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



Xradia 800 Synchrotron

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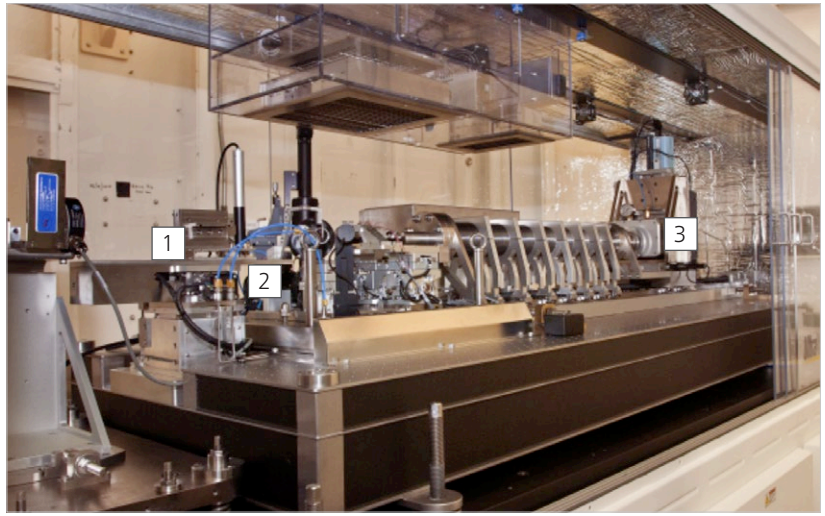
Based on transmission X-ray microscope (TXM) architecture and operating in the multi-keV range, Xradia 800 Synchrotron is a flexible imaging solution for your ultra-high resolution 3D tomography. ZEISS proprietary X-ray optics such as capillary condensers and zone plates in combination with a proven nano-tomography platform enable unparalleled image quality and throughput while offering flexibility for advanced techniques such as *in situ* and spectroscopic imaging.



Key benefits and specifications:

- 5-11 keV energy range
- Ultra-high spatial resolution down to 30 nm
- Absorption and Zernike phase contrast
- 4D imaging and *in situ* experiments: characterizing specimens over time and under varying conditions
- Spectroscopic imaging for elemental and chemical contrast (XANES)
- Automated image alignment for tomographic reconstruction

1 Incident X-ray beam
2 Sample and optics environment
3 Motorized detector

Xradia 825 Synchrotron

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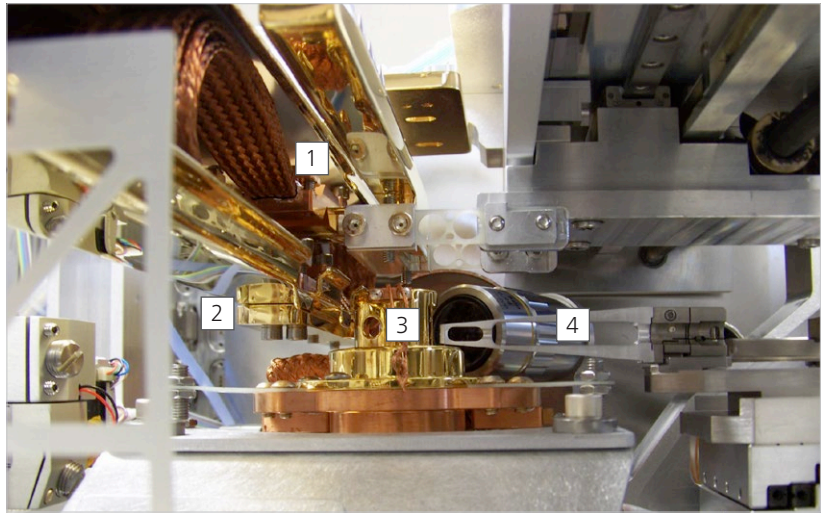
Xradia 825 Synchrotron uses many of the same optics and principles as Xradia 800 Synchrotron while operating in the soft X-ray range. In the “water window” energy range between the absorption edges of Carbon (284 eV) and Oxygen (540 eV), you can image organic materials in their natural, wet environment with high contrast. A unique cryogenic sample handling system with robotic sample exchange allows you to image such specimens at highest resolution while limiting the effects of radiation damage. Energies up to 2.5 keV are interesting for a variety of biological and materials science specimens.



Key benefits and specifications:

- 200 eV to 2.5 keV energy range
- Ultra-high spatial resolution down to 30 nm
- Zernike phase contrast optional
- Vacuum sample environment
- Cryogenic sample handling with robotic sample exchange to limit radiation damage
- Spectroscopic imaging for elemental and chemical contrast (XANES)

1 Sample exchange robot
2 Incident X-ray beam and condenser
3 Cryogenic sample stage
4 Zone plate optics

Cryogenic Sample Handling

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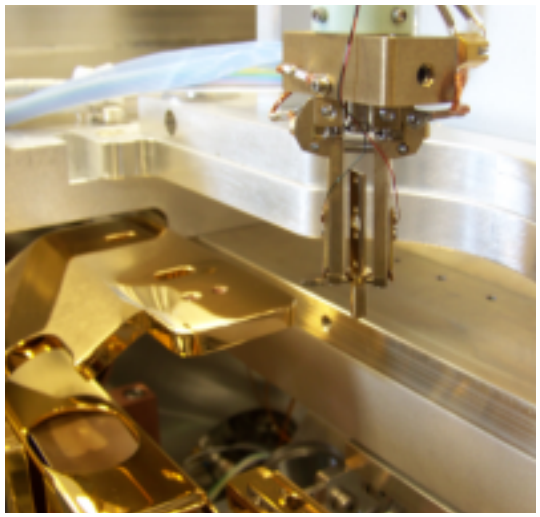
When you image on the nanoscale, cryogenic sample handling is essential to limit radiation damage to your organic specimens such as cells and tissue. ZEISS's patented cryo system is compatible with established TEM sample preparation methods and is optimized for the specific requirements of tomographic X-ray microscopy.

Cryo workflow:

1. Prepare and vitrify samples offline using a plunge- or high-pressure freezer
2. Load sample holders (e.g.grids) onto cartridges under liquid nitrogen, and then load cartridges onto transfer shuttle
3. Load transfer shuttle into microscope chamber through load lock
4. Load individual cartridges onto sample stage for imaging using sample exchange robot

Sample cartridge for TEM grids



Cryogenic sample exchange robot

Key benefits and features:

- Compatible with a variety of sample holders such as TEM grids, silicon nitride windows or capillaries
- Cartridge system limits direct handling of fragile samples
- Use of established sample preparation equipment such as plunge- or high pressure freezers
- Conductive cooling below 120K avoids sample exposure to cryogenic gases or liquids while imaging
- Robotic sample loading for high throughput imaging
- Automated sample transfer procedures with computer / touchscreen control

Precisely Tailored to Your Applications

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	Xradia 800 Synchrotron	Xradia 825 Synchrotron
Materials Research	Monitor battery electrode particles *in operando* during the charge-discharge cycle Perform chemical imaging of catalyst particles *in situ* Analyze SOFC nanostructure *in situ* at operating temperature	Perform chemical imaging of polymers by spectro-microscopy
Life Sciences	Study toxicity of nanoparticles in cells and tissue Image and quantify the nanostructure of bone	Visualize ultrastructure in whole, unsectioned cells in the frozen hydrated state Correlate X-ray and optical fluorescence microscopy for combined structural and functional imaging
Natural Resources, Geo- and Environmental Sciences	Visualize morphology of iron melt at Earth's lower mantle conditions Study microstructure of soil particles relevant to water retention	Study micro-organisms in wet environments
Electronics	Image integrated circuits to find malicious modifications	Image magnetic domains on the nanoscale

ZEISS Xradia Synchrotron at Work

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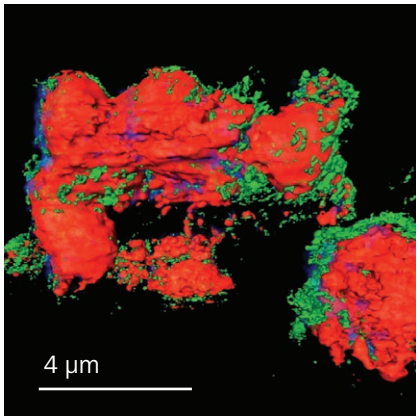
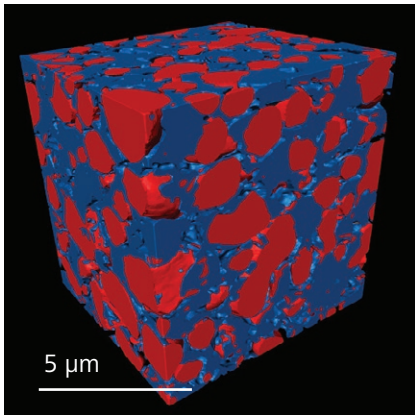
Xradia 800 Synchrotron

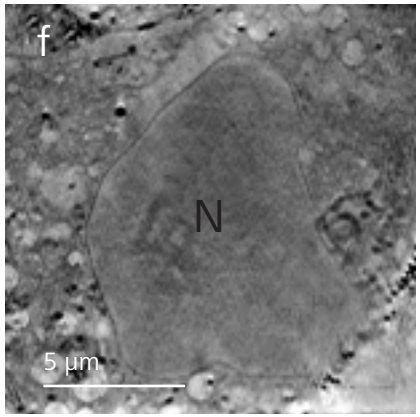


3D image of the chemical composition of a Nickel battery electrode (red: NiO, green: Ni)
Image courtesy of Y. Liu et al, SSRL

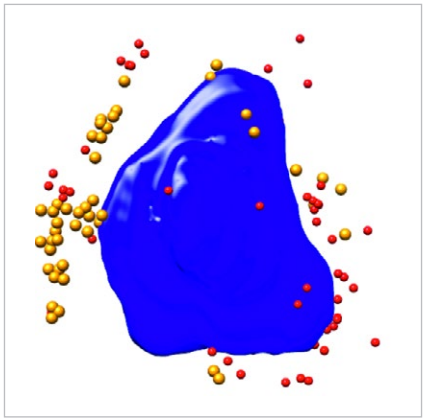


Multi-phase imaging of a solid oxide fuel cell (SOFC) electrode

Xradia 825 Synchrotron



Virtual cross-section through a virus infected Ptk2 cell.
Image courtesy of F.J. Chichon et al., CNB-CSIC and ALBA Synchrotron (Spain)



Segmented 3D rendering of the cell above.
Blue: Nucleus, red/orange: virus particles.
Image courtesy of F.J. Chichon et al., CNB-CSIC and ALBA Synchrotron (Spain)

Technical Specifications

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	Xradia 800 Synchrotron	Xradia 825 Synchrotron
Microscope Type	TXM[1]	TXM[1]
Energy range (typical)	5-11 keV	0.2 – 1.2 keV Up to 2.5 keV (optional)
Spatial resolution	30-60 nm	30 nm
Field of View	20-40 µm	16 µm
Exposure times	Beamline and application dependent	Beamline and application dependent
Sample environment	Air (vacuum optional)	Vacuum
Cryogenic sample handling	Optional	Optional
Contrast modes	Absorption Zernike phase contrast XANES	Absorption Zernike phase contrast (optional) XANES
Beamline recommendation[2]	Wiggler, Bending Magnet or Undulator	Wiggler, Bending Magnet or Undulator
Features	Automated image alignment for tomographic reconstruction Integrated Visible Light Microscope for sample alignment EPICS or TANGO interface for monochromator control Integration of *in situ* stages possible	Integrated Visible Light Microscope for sample alignment EPICS or TANGO interface for monochromator control Correlative fluorescence light microscope (optional)

1. TXM: Transmission X-ray Microscope (Full-field microscope)
2. Contact ZEISS for recommendations on beamline design and layout

Specifications are typical and subject to change. Contact ZEISS for details and customization options.

Unique X-ray Optics

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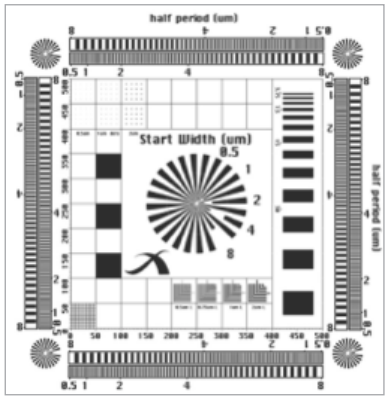
ZEISS employs proprietary X-ray optics in the Xradia Synchrotron family of microscopes:

- Reflective capillary condensers, precision-fabricated to match source properties and imaging optics with maximum flux density
- Fresnel zone plates, used as objective lenses to achieve both high resolution and efficiency
- Phase rings, for Zernike phase contrast
- High contrast and high efficiency detectors based on scintillators, optically coupled to a CCD detector



Zone plates and resolution targets are available from ZEISS for purchase. Please contact us for details.

Count on Service in the True Sense of the Word

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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.

Our service on-demand also brings you distinct advantages. ZEISS service staff will analyze issues at hand and resolve them – whether using remote maintenance software or working on site.

Enhance Your Microscope System.
Your ZEISS microscope system is designed for a variety of updates: open interfaces allow you to maintain a high technological level at all times. As a result you'll work more efficiently now, while extending the productive lifetime of your microscope as new update possibilities come on stream.

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

>> www.zeiss.com/microservice

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

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