Product Information
Version 1.0

# ZEISS Crossbeam 340 and Crossbeam 540

## Your FIB-SEM for High Throughput Nanotomography and Nanofabrication

We make it visible.

# Enjoy Productivity with an Open 3D Nano-Workstation



Speed up your tomography runs and use high FIB currents with excellent spot profiles to bridge the gap between micro- and nanopatterning.

Take full control of FIB processing and enjoy the benefits of live FE-SEM monitoring. Perform complex, leading-edge applications, thanks to Crossbeam's modular platform concept, an open and easily extendable software architecture and unique solutions for demanding, charging or magnetic samples.

Combine the powerful imaging and analytical performance of the GEMINI column with the superior processing ability of a next-generation FIB to form a complete 3D nano-workstation.


Animation

# Simpler. More Intelligent. More Integrated.



**Gain More Information in Less Time**

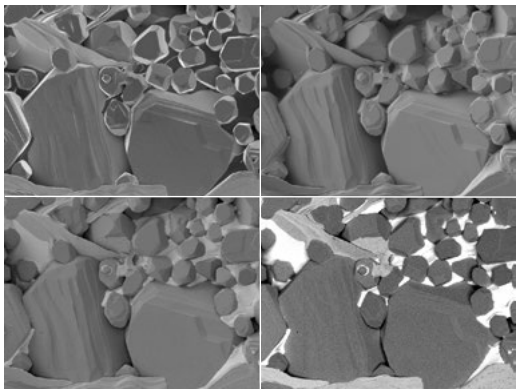
Speed up your sample preparation, nanofabrication and FIB-milling: with Crossbeam you combine the excellent low kV FE-SEM performance of the GEMINI column with FIB currents of up to 100 nA. With multi-detector acquisition, superb SEM resolution under analytical conditions and the ability to mill and image simultaneously, you will be retrieving maximum information in the shortest possible time. With GEMINI technology you examine large fields of view of up to 50 k x 40 k pixels with uniformly high resolution. Count on advanced solutions for your workflows and speed up drawn-out 3D applications such as tomography, 3D analytics and TEM lamella preparation.

**Keep Complete Process Control**

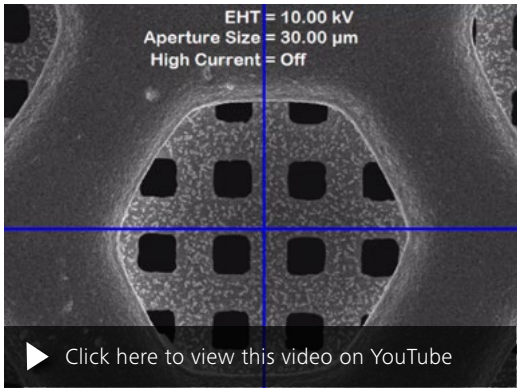
Your Crossbeam system is designed for maximum stability during demanding long-term experiments. The electron and ion beam column provide a uniform beam profile over a long time. Thanks to the GEMINI lens design you profit from high resolution imaging while milling. Easily change system parameters such as probe current or acceleration voltage in real time during your acquisition. Profit from maximum possible sample variety and experience of an easy-to-understand graphical user interface (GUI) and short time-to-image.

**Experience Maximum Flexibility**

The Crossbeam workstation can be tailored to your individual applications – today and in future. Based on a modular concept, you easily upgrade your system with a wide range of detectors and accessories. Customize your Crossbeam for various *in situ* experiments – for instance, tensile or stress testing, SIMS or CL, cryo or heating. The open application programming interface (API) gives you access to every microscope parameter. Create your own automation of complex operation sequences and leverage your Crossbeam to perform tasks that no one has yet been thinking of.



*Detect up to four signals simultaneously.*




*Change probe current and acceleration voltage without image adjustments.*

# Your Insight into the Technology Behind It

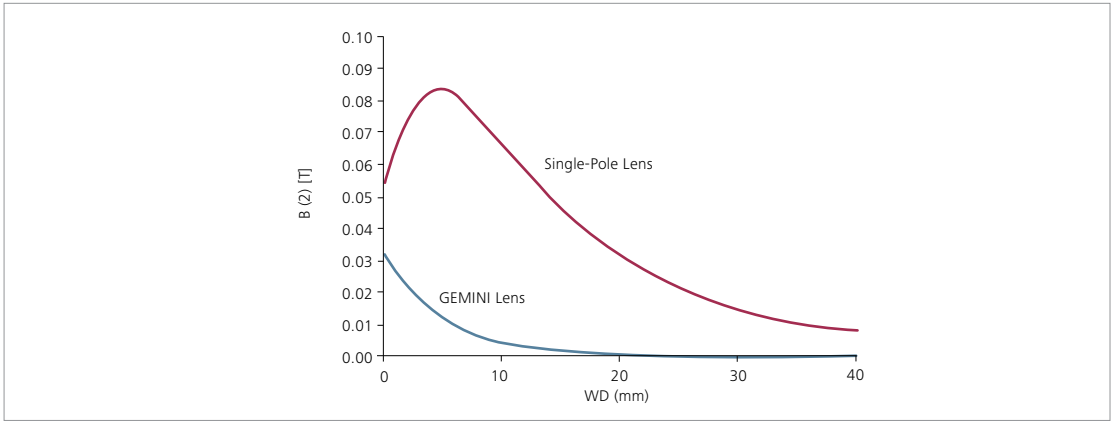


**Build on a Solid Foundation**

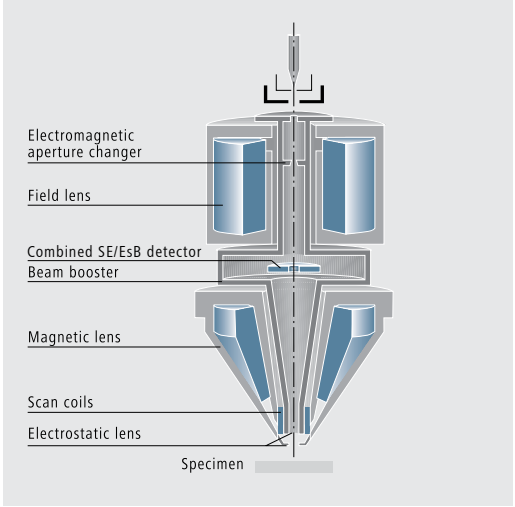
Crossbeam combines a versatile FE-SEM platform with a chamber suitable for any FIB-SEM application. From this starting point, you can tailor the Crossbeam workstation to meet whatever demands your individual applications make – now and in years to come. The FE-SEM column of Crossbeam is based on proven GEMINI technology. You will appreciate the long-term stability of your SEM alignment and the effortless way to adjust all system parameters such as probe current and acceleration voltage. Unlike other FE-SEM's, GEMINI does not expose your specimen to a magnetic field. This allows you to achieve distortion-free, high resolution imaging over large fields of view as well as tilting without influencing the electron optical performance. Even magnetic samples can be imaged easily.

**Choose between Two Columns:**

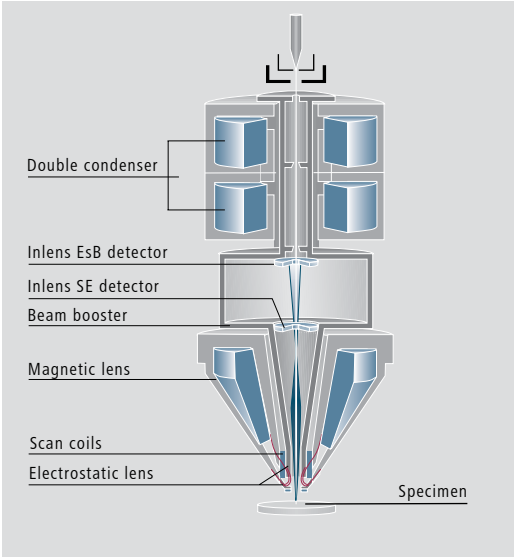
- The GEMINI I VP column of Crossbeam 340 gives you maximum sample flexibility and multi-purpose environments. With Variable Pressure (VP) you perform *in situ* experiments, even with outgassing or charging samples, under excellent analytical conditions. The optional Inlens Duo detector provides the unique GEMINI material contrast.
- The GEMINI II column of Crossbeam 540 with its double condenser system enables high resolution even at low voltage and high current. It's ideal for high resolution imaging and fast analytics. Simultaneous Inlens SE and EsB imaging provides unique topographical and material contrast. You gain more information in less time.




*Magnetic field leakage of the GEMINI lens compared to a traditional single pole lens design. The minimum magnetic field on the sample allows highest ion and electron beam performance on a tilted sample as well as high resolution imaging of magnetic materials.*




*GEMINI I VP column (Crossbeam 340)*



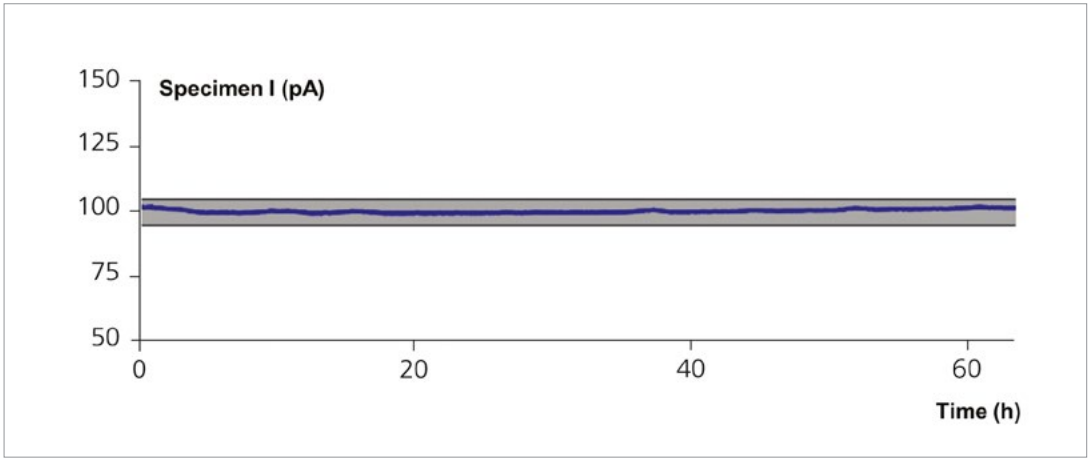

*GEMINI II column (Crossbeam 540)*

# Your Insight into the Technology Behind It

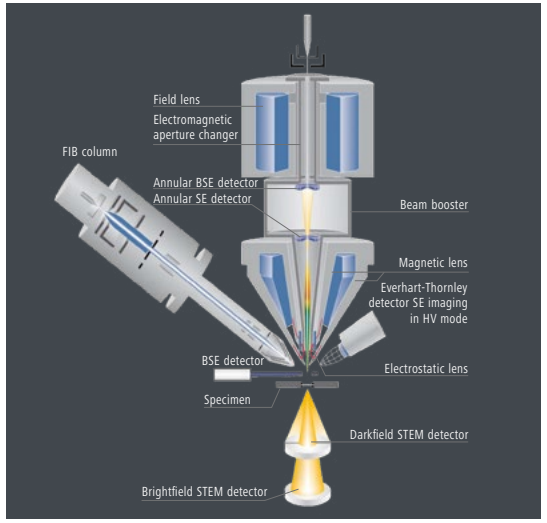


**From Massive Ablation to Nanometer Precision: One FIB Does it All**

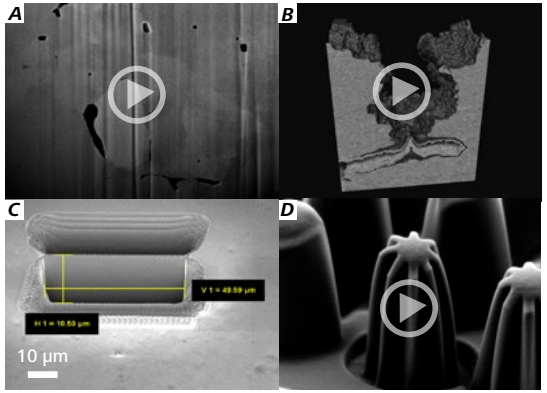
Double the speed of your 3D FIB-SEM applications by working with the highest gallium ion beam current available in any FIB-SEM. Get precise and reproducible results with maximum stability during the acquisition time. The column design gives you access to five orders of magnitude of beam current. The larger beam currents of up to 100 nA allow fast and precise material removal and milling processes. What's more, this column also performs exceptionally well at low currents, with the smallest probe size at less than 3 nm at 1 pA. You achieve high resolution at different acceleration voltages down to 500 V. This allows e.g. finest polishing of TEM lamella with minimum amorphous surface layer.




*An excellent long-term stability is essential for 3D-FIB applications. Your ZEISS FIB guarantees specimen current stability of +/- 5% over 72 hours.*




*Arrangement of FIB- and FE-SEM column in Crossbeam systems with an inclination angle of 54°.*




*Many applications will benefit greatly from the increased available current and the outstanding performance over the whole current range. A) Preparation of cross-section in steel, B) 3D reconstruction of crack in steel sheet; Sample: courtesy of AUDI AG, C) Large TEM lamella (50 µm x 20 µm) prepared automatically in 25 min , D) Patterning of flower-type AFM tip*

# Expand Your Possibilities



**With the Laser Option You Perform Material Ablation and Fabrication from the Millimeter to the Nanometer Range.**

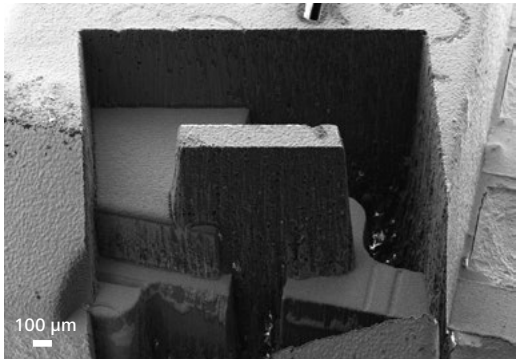
Upgrade your Crossbeam system with an optional laser ablation to perform sample preparation where conventional methods are too slow or complex. Combine it with the high current FIB and you can fabricate functional structures ranging from the millimeter to the nanometer range. With one system.

**Applications:**

- Open up deeply buried target areas for further FIB-SEM work.
- Trim brittle phases such as glass fibers or ceramics.
- Trim soft samples where mechanical preparation causes smearing, delamination or compression.
- Trim samples with complex geometries that cannot be prepared with microtomes.
- Fabricate functional structures such as microfluidic devices and MEMS.
- Prepare any material for further EDS and EBSD analytics.

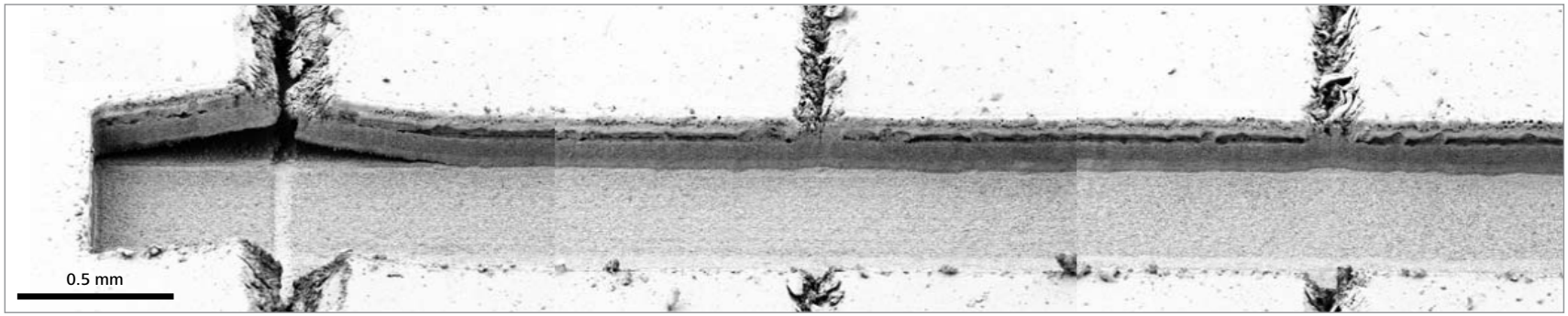
**ZEISS Crossbeam with the Laser Option Offers:**

- The fastest technology for massive ablation
- Multi-scale processing over six orders of magnitude in one tool
- Contamination-free SEM chamber
- Reliable, industry-proven technology at the lowest cost of ownership




*Hall Sensor: A 1.7 x 2.2 x 0.5 mm³ large volume of mold compound was removed in 70 sec. for further analysis in FIB-SEM.*


*Sample preparation with laser followed by FIB-SEM processing.*




*Evaluation of scratch resistance tests: a large volume (9.0 x 0.5 x 0.2 mm³) of material was removed by the laser within 30 s to expose the scratches in cross-section. Sample courtesy of AUDI AG*

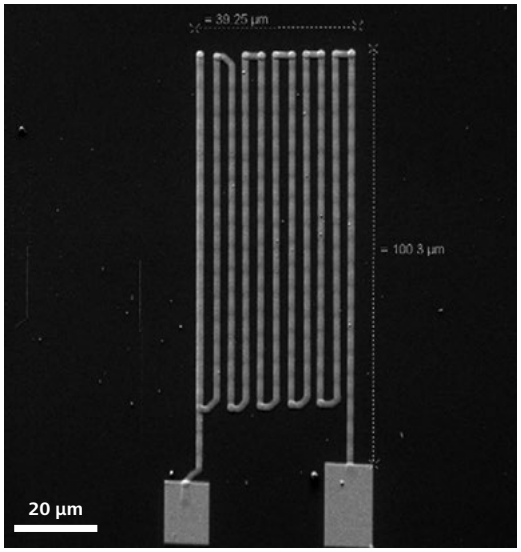
# Expand Your Possibilities



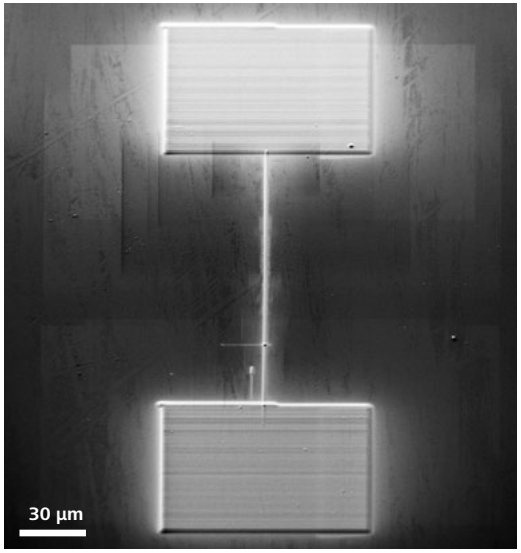
**Customize Your Crossbeam with the Remote Application Programming Interface**

Your innovative experiments often require new functionality beyond what is provided by the operating software of your electron microscope. The open programming interface of Crossbeam allows access to almost every microscope parameter available. The remote API lets you take complete control over electron and ion optics, stage, vacuum system, detectors, scanning and image acquisition from custom programs, running on the system PC or a remote workstation.

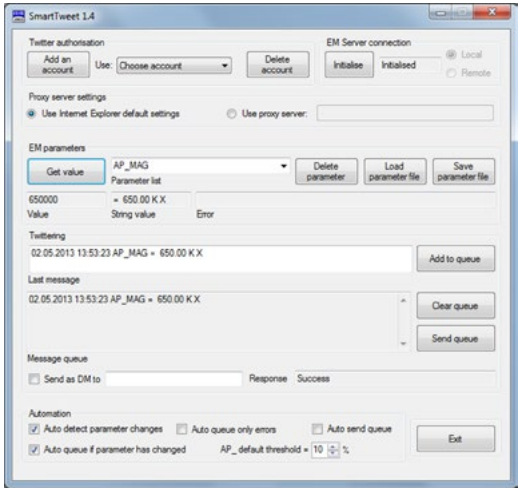
ZEISS will provide documentation, code examples in various programming languages and technical support to make sure you get the results you want. Quickly. The SmartSEM API development webforum offers you online expert support and discussion with other developers. Please visit www.zeiss.com/smartsem-api.




*Micrometric strain gauge prototype produced with the large distance line deposition application.*




*Electrical resistance measurement setup (tilted view). Two pads of 100 µm x 100 µm were connected with a metal line with a width of 1 µm and a length of 200 µm. Instead of moving the ion beam over a long distance and accepting varying deposition quality, the sample was moved while the ion beam remained stationary. The API application for depositing long and homogenous metal line patterns was programmed by experts from ZEISS in a few days only.*




*The custom application SmartTweet monitors microscope parameters through the API and sends parameter values and error messages via the online service Twitter. You profit from fast, worldwide remote monitoring of long-term experiments with your Crossbeam.*

# Expand Your Possibilities



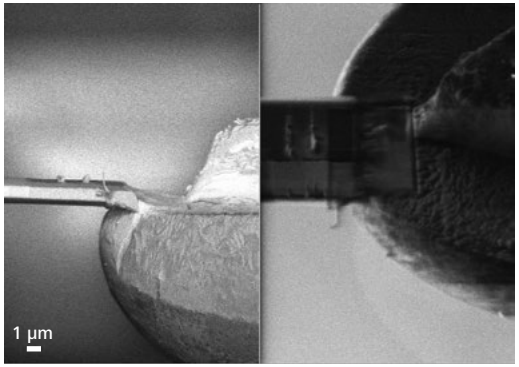
**Create the Thinnest, Most Stable TEM Lamellas – Automatically**

Crossbeam has all the features you would expect from a tool designed for lamella preparation:

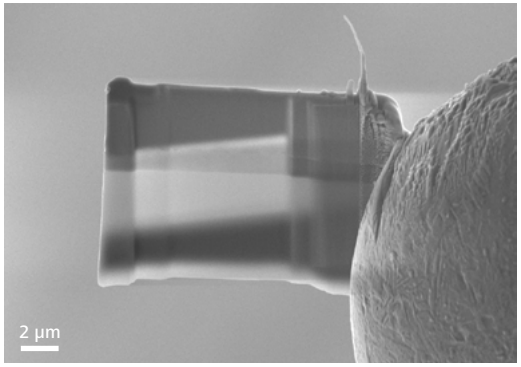
- A focused ion beam with a 100 nA milling current for the highest throughput of any FIB-SEM.
- An automated workflow that prepares large amounts of TEM lamellas on user-defined positions of your sample.
- A revolutionary patented way to prepare stable lamellas thinner than 10 nm.

**How it Works**

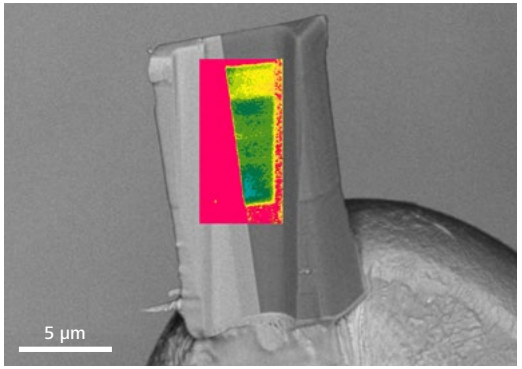
1. Load your sample and start the Automated Sample Preparation (ASP) Wizard.
2. Set all parameters – such as the number, position or geometry of the lamella.
3. Start the workflow. All defined lamellas are prepared automatically and without supervision.
4. Lift out your lamellas and do the final polishing with the patented $X^2$-preparation method. You achieve homogenous thicknesses of <10 nm without bending or shrinking of the lamella.




*TEM lamella soldered on manipulator tip.*




*TEM lamella after final thinning with $X^2$-method. The lamella shows a stable frame around the transparent area.*




*Thickness of lamella inspected with Smart EPD endpoint detection software.*

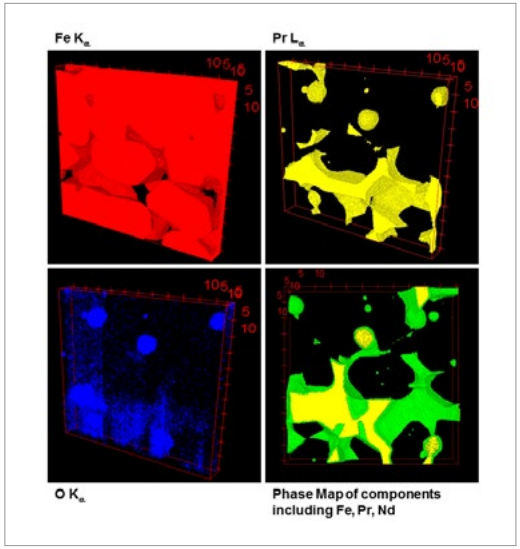
# Expand Your Possibilities



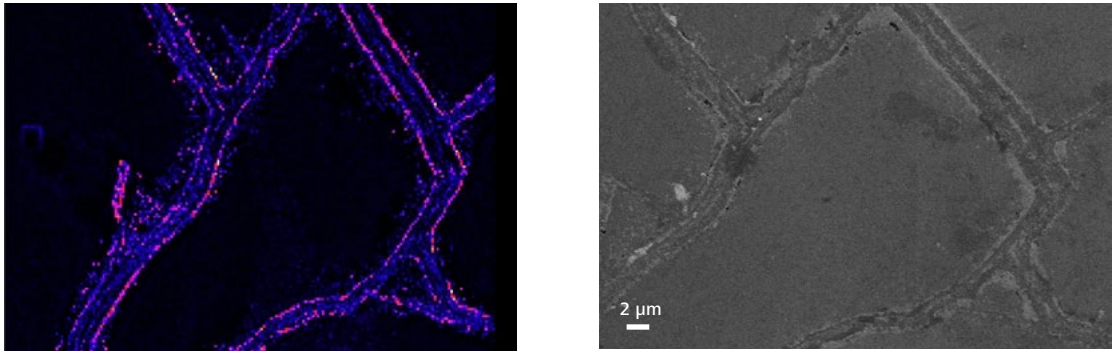
**Advanced Analytics**

To understand and improve modern materials and compositions, the analytical capabilities of a FIB-SEM become increasingly important. Crossbeam offers a wide range of solutions that allow you to analyze elemental, structural and crystalline information, grain and texture. The characterization can be performed in three dimensions.

- Obtain unique 3D data of your sample created with fast and intuitive workflow solutions for 3D EDS and EBSD.
- Analyze trace elements down to ppm level of thin films, semiconductors or solar cells and detect isotopes and ions with 50 nm lateral analytical resolution by using a SIMS detector.
- Examine the internal structure of your samples and study surface plasmon modes in your nanostructures by an optional Cathodoluminescence (CL) detector.
- Detect failures in your semiconductor devices and image low currents in your samples with Electron Beam Induced Current (EBIC) solutions.




*Reconstructed volume of state one $Nd_2Fe_{14}B$ magnet. Cuboids of iron ($FeK_\alpha$, red) praeseodym ($PrL_\alpha$, yellow) and oxygen ($OK_\alpha$, blue) are shown. The forth cuboid shows the binder phase which contains Fe, Pr and Nd. An iron rich phase is shown in green.*

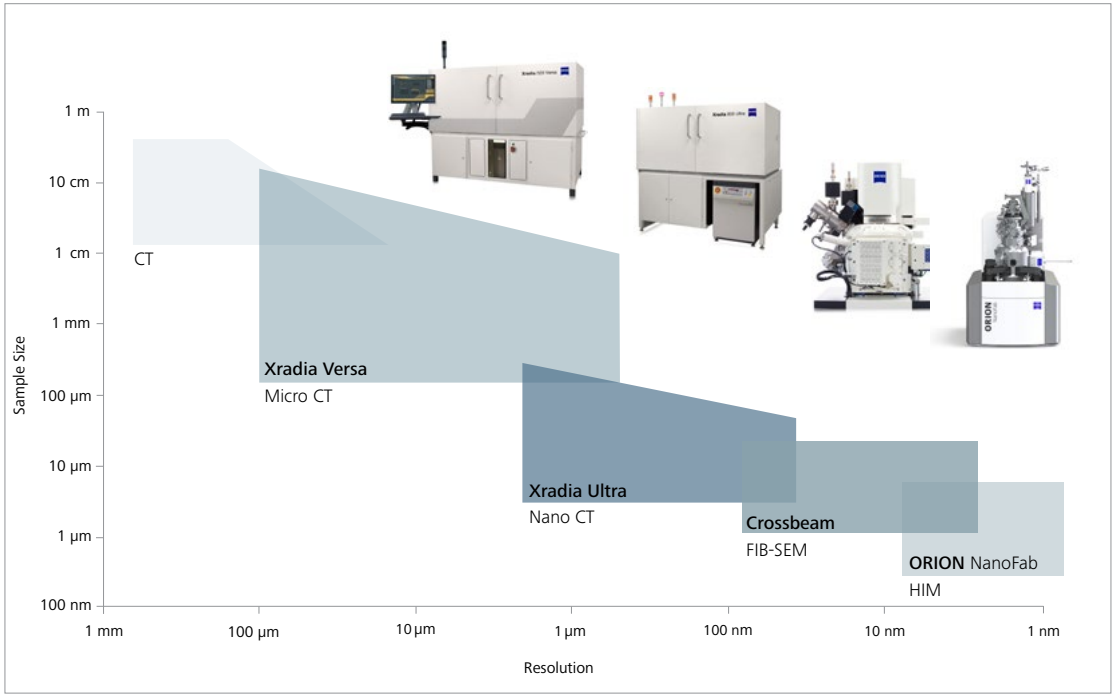



*$Al^+$ image showing Al concentration at a grain boundary of a LaSrCuFe oxide sample. Left: SIMS image; Right: SE-image; Sample: courtesy of R. Chater, Imperial College London, UK; instrument: FIB-SEM with Hiden SIMS*

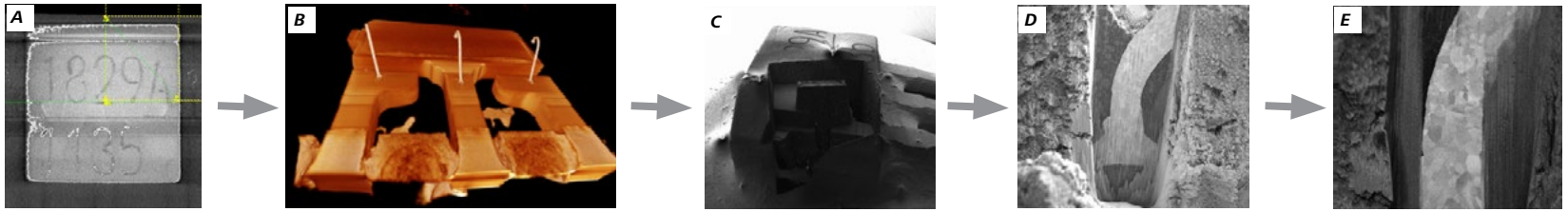
# Expand Your Possibilities



Your applications increasingly demand multiscale and multimodal imaging and analytics. Choose your technologies from the unique portfolio of light, X-ray, electron and ion microscopes from ZEISS. You profit from optimized workflows for sample transfer and image correlation between the different systems. Use your ZEISS X-ray microscope to get structural infor-mation of your sample non-destructively in the micrometer scale. You analyze the surfaces, geometries and different phases inside your sample and conduct *in situ* studies under realistic external conditions. Use the FIB of your Crossbeam to precisely access the region of interest defined in your X-ray image and then perform your high resolution imaging and analytics.




*The ZEISS multiscale portfolio: non-destructive 3D X-ray metrotomography with Xradia Versa and Xradia Ultra; fast and precise FIB processing with excellent FE-SEM imaging and analytics on Crossbeam; unique contrasts and sub-nm imaging with ORION NanoFab.*




*Correlative 3D-workflow: A) Hall sensor with internal defects, B) X-ray 3D image to localize bond wires and connections, C) Open sample with massive ablation laser and release Region of Interest, D) Fine polishing of defect structure using focused ion beam, E) HR imaging of defective area*

# Tailored Precisely to Your Applications



| Typical Applications, Typical Samples | Task | ZEISS Crossbeam Offers |
|---|---|---|
| **Cross-Sectioning and Tomography** | Acquire high resolution images of your cross-section. Image and reconstruct volumes of your sample to get 3D information. | Crossbeam offers a wide range of different detection and analysis technologies, allowing a unique characterization of your sample. The Inlens EsB detector provides excellent material contrasts and can be used simultaneously with the focused ion beam. This speeds up long-lasting tomography runs. You can also acquire different detector signals simultaneously so you will get more information from your sample. The GEMINI lens design does not expose your sample to a magnetic field which allows large fields of view with homogenously high resolution. An image dimension of up to 50 k x 40 k makes stitching unnecessary. Intelligent software algorithms enable long and unattended tomography runs for best results in the shortest time. |
| **3D-Analytics** | Characterize elemental distributions, phases and the microstructure of a material such as crystal orientation, texture, stress and strain conditions. | For efficient use, different packages are provided for fully automated acquisition of 3D EDS datasets. These allow you to gather compositional information easily, even with challenging samples (magnetic or charging), in three dimensions. Crossbeam is also the perfect tool for 3D electron backscatter diffraction (EBSD). This allows complete analysis of the microstructure of crystalline materials. The analytical performance of Crossbeam enables precise and time-efficient results. |
| **TEM Lamella Preparation** | Prepare ultra-thin and stable samples for further analysis in a TEM in an automated fashion | Crossbeam offers a complete solution for the preparation of TEM lamellas. A user-friendly wizard helps to prepare numerous TEM lamellas, unattended. For the final thinning, Crossbeam provides a solution for creating the thinnest and most stable TEM lamellas by combining a high resolution FIB with the patented $X^2$-preparation method. End-point detection software gives you accurate information about the thickness of your lamella. |
| **Nanopatterning** | Create structures and modify surfaces of the sample with the ion or electron beam and different gases. Create surfaces with improved electronic, magnetic, optical and mechanical properties. | Get the best possible results with the integrated solution for lithography and structuring applications. You perform these tasks in real time with full control, observing the process with your SEM image. Just drag the shapes you want to create in your SEM image, set up the parameters and start patterning. For advanced fabrication tasks, Crossbeam lets you plan your work offline before you start. Design the most complex nanostructures, backed by multi-layer support, structure libraries and a large parameter space. For standard applications, the system's user-friendly workflows help new users to achieve great results. As tasks become more sophisticated, the software allows you to access almost any SEM, FIB or GIS parameter available to keep full control over your patterning tasks. |

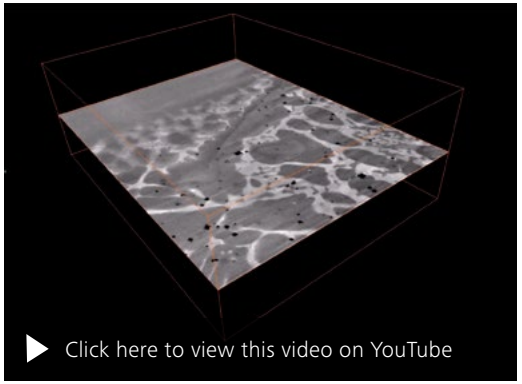
# ZEISS Crossbeam at Work



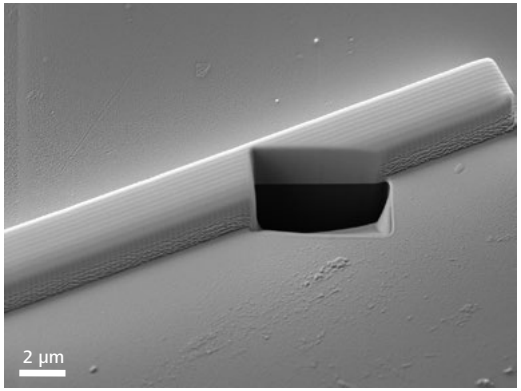
## Material Science Applications


*Nanocrystalline layers of silver salts of ISO 400 color film. Height: 20 µm; Volume reconstruction rendered from image stack acquired in automated overnight data run.*


*3D reconstruction of dendritic structure in Al-Cu eutectic alloy imaged with Inlens EsB detector. Sample: courtesy of Los Alamos National Laboratory, New Mexico, USA*

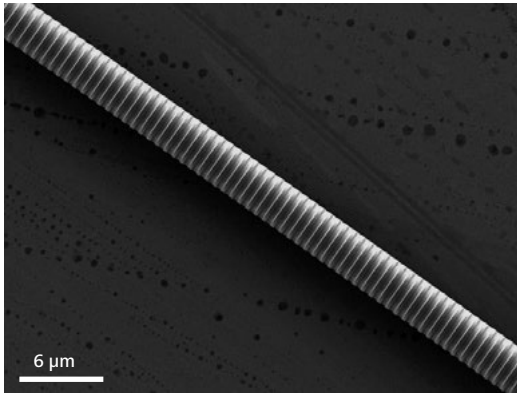



*Interface of laser welded NiTi and stainless steel wires. Reconstruction of different phases at transition. Sample: courtesy of P. Burdet, EPFL, Switzerland*




*Deposition of tungsten (W), volume of 20 x 2 x 1 µm³ created in less than 4 min.*

*Ultra-thin TEM lamella showing interface zone on Si. Transparent area is homogeneously thin.*

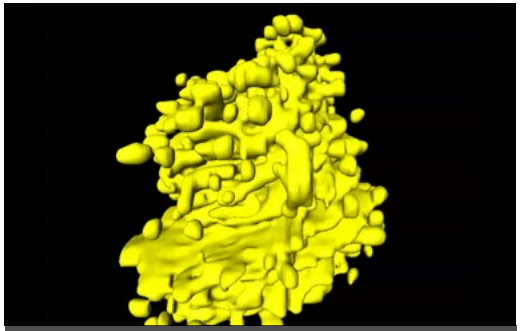



*Non-conductive fibre; optical grating created with flood gun for charge neutralization.*

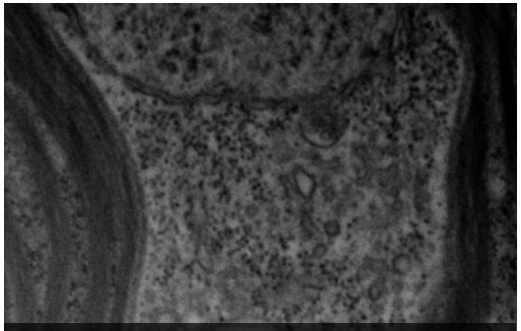
# ZEISS Crossbeam at Work



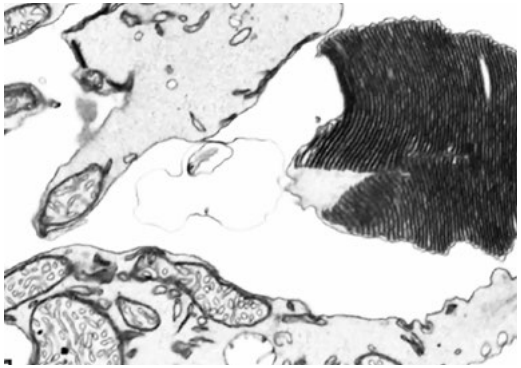
## Life Science Applications



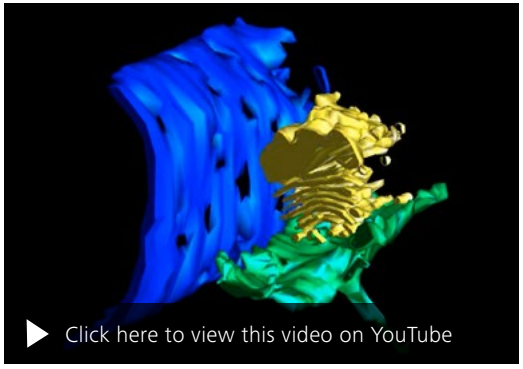

*3D reconstruction (Imaris) of Golgi apparatus in algae. Connections between cisternae. Data: courtesy of Prof. C. Hawes, Brookes University, Oxford, UK*




*3D data stack of interacting cell compartments in algae.*

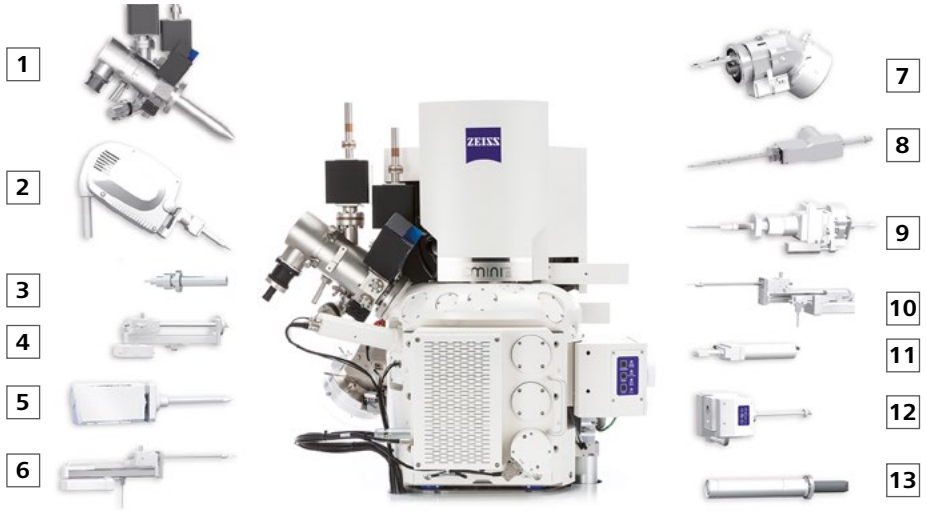


*Resin embedded sample of mouse retina; virtual x/z section. Voxel size 4 x 4 x 4 nm³. Sample: courtesy of B. Roska and C. Genoud, FMI, Basel, Switzerland; Data: courtesy of M. Cantoni, Centre Interdisciplinaire de Microscopie Electronique (EPFL-CIME), Lausanne, Switzerland*




*3D reconstruction (IMOD) of Golgi stack (yellow) of algae getting in contact with cell nucleus (blue), and ER (green).*

# Your Flexible Choice of Components




**Available Options**

1. Capella Focused Ion Beam (FIB) column
2. WDS for highest sensitivity chemical analysis
3. Electron flood gun allows ion beam preparation of non-conductive samples
4. Local charge compensation allows SEM imaging and analysis of non-conductive samples
5. EDS for fastest chemical analysis
6. Annular STEM detector (aSTEM) for TEM like imaging and quality control
7. Multichannel Gas Injection system (GIS) for up to 5 precursor materials on a single flange
8. Single needle GIS for high angle sample access
9. Manipulators for sample modification and probing
10. BSD4 detector for high efficiency and angle selective material characterization. Detection of up to 4 channels in parallel possible
11. EsB detector for finest z resolution without topographic artefacts and unique material contrast (Crossbeam 540 only)
12. Airlock solution (80 mm or 200 mm wide) for fast and efficient sample transfer and fast pumping times
13. EBSD for crystalographic mapping

**Further Options**

- Crossbeam 340: Inlens Duo Detector for SE or EsB imaging
- SESI detector for Secondary Electron and Secondary Ion imaging
- Nanopatterning and Visualization Engine (NPVE) for advanced patterning and lithography tasks
- Plasma Cleaner
- Electrostatic Beam Blanker for SEM
- Rapid Laser Ablation Upgrade
- Further options on request

# Technical Specifications



| | ZEISS Crossbeam 340 | ZEISS Crossbeam 540 |
|---|---|---|
| **Imaging** | Schottky Emitter | Schottky Emitter |
| | 1.9 nm @ 1 kV | 1.8 nm @ 1 kV |
| | 1.0 nm @ 15 kV | 0.9 nm @ 15 kV |
| | 0.9 nm @ 30 kV (STEM mode) | 0.7 nm @ 30 kV (STEM mode) |
| | Beam current: 5 pA – 100 nA | Beam current: 10 pA – 300 nA |
| **Ga FIB** | LMIS: Lifetime: 3000 µAh | LMIS: Lifetime: 3000 µAh |
| | Resolution: <3 nm (statistical method) | Resolution: <3 nm (statistical method) |
| | Beam current: 1 pA – 100 nA | Beam current: 1 pA – 100 nA |
| **Detectors** | Inlens SE, Inlens Duo, ETD, SESI, STEM, BSD, CL | Inlens SE, EsB, ETD, SESI, STEM, BSD, CL |
| **Stage** | X = 100 mm, Y = 100 mm | X = 100 mm, Y = 100 mm |
| | Z = 50 mm, Z' = 13 mm | Z = 50 mm, Z' = 13 mm |
| | T = -4° to 70°, R = 360° | T = -4° to 70°, R = 360° |
| **Vacuum System** | Charge Compensation | Charge Compensation |
| | Variable Pressure | |
| **Gases** | Single GIS: Pt, C | Single GIS: Pt, C |
| | Multi GIS: Pt, C, W, Au, $H_2O$, $I_2$, $SiO_x$, $XeF_2$ | Multi GIS: Pt, C, W, Au, $H_2O$, $I_2$, $SiO_x$, $XeF_2$ |
| **Scan Field** | 32 k x 24 k (up to 50 k x 40 k with optional ATLAS 3D) | 32 k x 24 k (up to 50 k x 40 k with optional ATLAS 3D) |
| **Analytic Options** | EDS, EBSD, WDS, SIMS | EDS, EBSD, WDS, SIMS |
| **Advantages** | Maximum sample variety due to variable pressure mode, wide range of *in situ* experiments, sequential SE/EsB imaging possible. | High throughput in analytics and imaging, maximum ease of use, high resolution under all conditions, simultaneous SE and EsB imaging. |

# 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.

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Our service on-demand also brings you distinct advantages. ZEISS service staff will analyze issues 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: 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.

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

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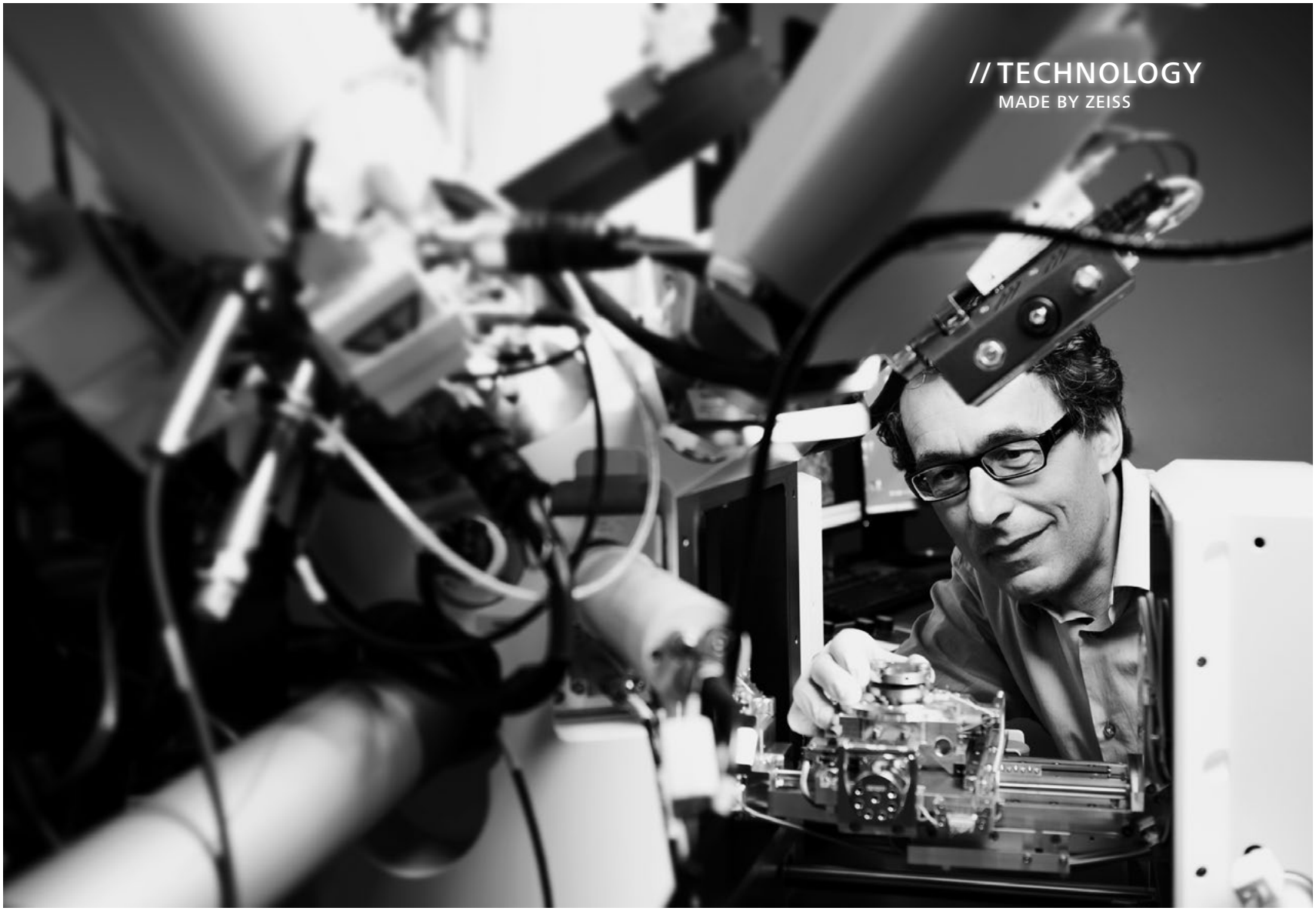
The moment "I think" becomes "I know".
**This is the moment we work for.**





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