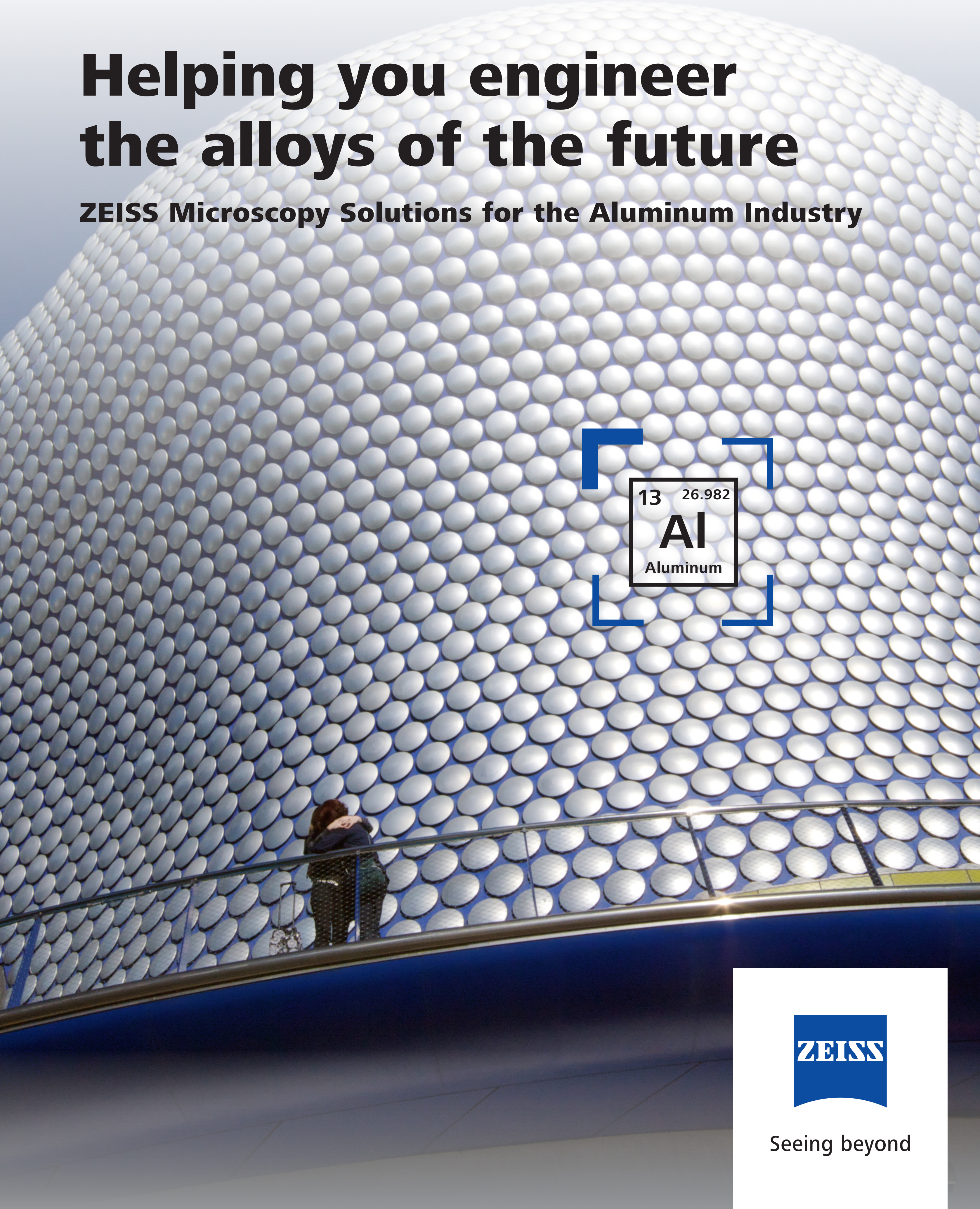
Helping you engineer the alloys of the future

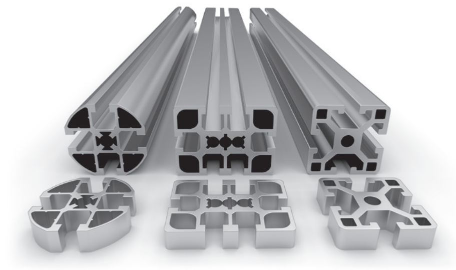
ZEISS Microscopy Solutions for the Aluminum Industry



Seeing beyond

Advancing aluminum through microstructural insight

Metallurgists and engineers continue to push the boundaries of what is possible to achieve in construction and mobility, to challenge the accepted wisdom of what metals can do, faced with ever increasing resource scarcity. And the higher the requirements of automotive, structural and transportation alloys, the greater need for understanding and engineering metals at the micron and nanometer scale.

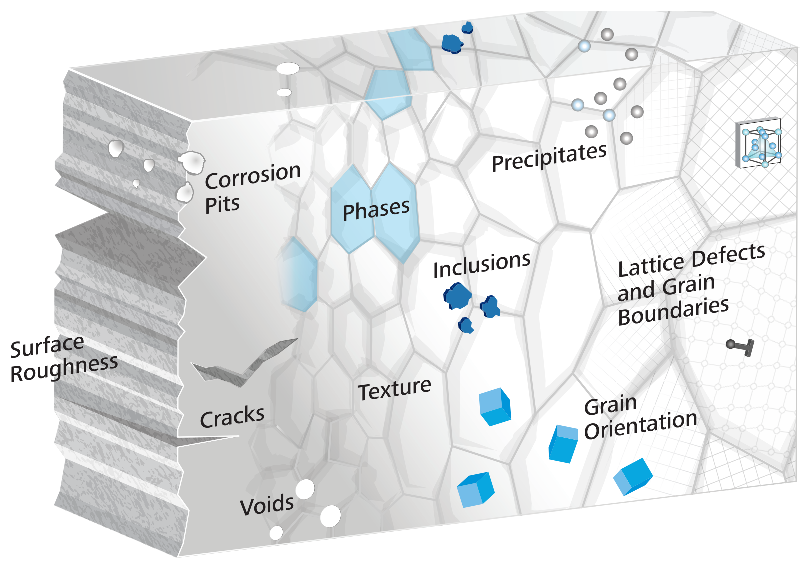


More and more, they turn to aluminum to meet the world's sustainability and mobility challenges, for its lightness, strength, corrosion resistance, formability, ductility, conductivity and non-toxicity, even in applications where steel or copper have traditionally been applied.

ZEISS solutions can help you extract information from aluminum samples on scales from the millimeter to the nanometer, whether imaging and measuring features, chemical and crystallographic analysis of inclusions, grains and phases, or textural and structural information in three dimensions, in turn meeting the needs of your customers and our world.

By advancing the microscopy spectrum, ZEISS can help you advance aluminum with a full multiscale portfolio of light, electron, X-ray and ion beam microscopes for routine and research applications, with an industry-leading suite of software solutions.

These will unlock information about your materials with light, electrons and X-rays. Microstructural analysis of metals is the eyesight of the metallurgist, bringing deep physical and chemical understanding of properties and performance.



Microscopy generates actionable data streams on multiple length scales

Illuminating grains, inclusions and texture with light microscopy

Aluminum is unique. The properties that make it so useful for the world's industrial needs also require different techniques to ferrous metallurgy. Optical microscopy and automated image analysis can provide a window into the micro world, validate age hardening and annealing processes through grain size analysis, or precisely measure layer thickness in coatings and anodization.

Multiphase analysis of complex or porous alloys deepens the understanding of mechanical properties and predicts failures. Available custom solutions include coating porosity to standards, and dendrite arm spacing to correlate solidification, structure and strength.

Aluminum researchers and producers all over the world count on ZEISS light microscopes and ZEN software solutions for tasks from basic inspection and reporting, to automated layer thickness, assisted by user-friendly rapid machine learning segmentation.

Both routine and research tasks require reproducibility, precision and easy and fast control of the analysis tasks.

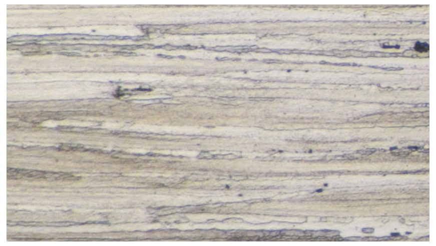
Connect your laboratory with smart solutions for automatic metallography: ZEISS ZEN Intellesis machine learning analysis, correlative microscopy with a scanning electron microscope, data storage, and the GxP traceability solution. Then ZEN Connect brings together your multiscale, multimodal data.

Connected software solutions

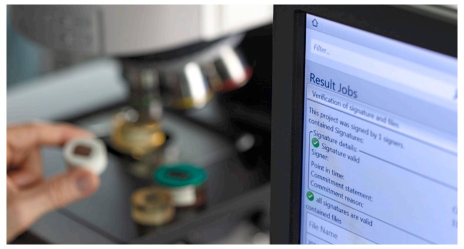
ZEN

The ZEISS ZEN core software suite unlocks the power of light microscopy with modular, turnkey solutions to extract and understand microstructural information: the small features that make a big difference to performance.

Grain Size to predict mechanical properties	**ZEN Connect** to overlay and connect multiple data streams
Multiphase for phase segmentation analysis	**ConfoMap** to assess roughness and texture
Interactive Measurement for measuring features	**Shuttle & Find** to enable correlative microscopy
Layer Thickness for coatings and corrosion	**Data Storage** solutions to handle large datasets
Intellesis segmentation by machine learning	**GxP** to control and audit routine microscopy



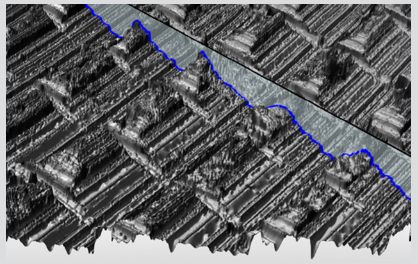
Aluminum alloy microstructure



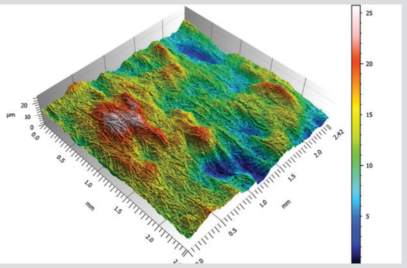
Configure your ZEISS light microscope with powerful connected software solutions

Powerful 3D textural analysis

ZEISS digital and confocal laser scanning microscopes, together with ZEISS ConfoMap software, scan rough, wavy or cracked surfaces, generating quantitative textural data that is critical in roughness and failure investigation, then reconstructing, imaging and reporting intuitively and fast.



3D view of milled aluminum surface



Color-coded height map, metal part

Nanometer insight into structure, chemistry and grains with SEM and FIB-SEM

Ever more demanding applications demand more advanced research. Understand metal performance at the smaller scales on which the grains, precipitates and inclusions in aluminum have profound effects on performance, resilience and safety. At the same time, resource efficiency and cost concerns are pushing producers to continuously improve extraction and recycling processes.

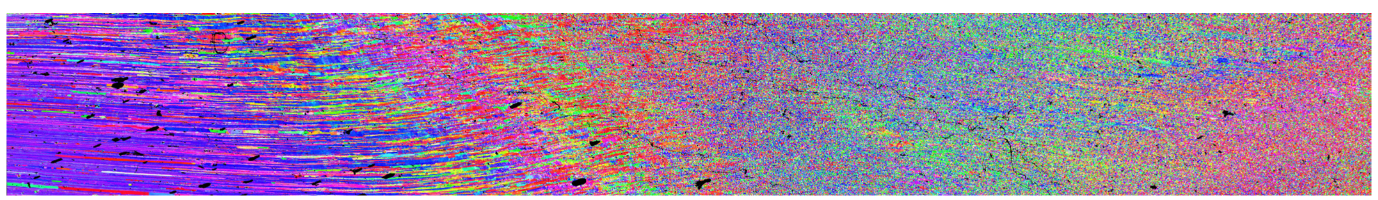
Scanning electron microscopy (SEM) provides simultaneous and intuitive imaging, chemical, crystallographic and structural analysis to enable deeper insight than ever before, becoming an essential research tool.

The ZEISS portfolio ranges from the flexible and user-friendly EVO, through the powerful Sigma range of workhorse field emission SEMs, and the GeminiSEM range of sub-nanometer analytical powerhouse instruments. All can be correlated with ZEISS light microscopes in fast intuitive multiscale workflows.

Build your SEM capability with advanced imaging detectors and accessories such as energy dispersive or wavelength dispersive X-ray spectroscopy (EDS, WDS) and integrated Raman for chemistry, electron backscatter diffraction (EBSD) for crystallography, or software to generate critical actionable information.

GeminiSEM 450 specialist FESEM for speed and surface sensitivity in imaging and analytics

Crossbeam 550 FIB-SEM for high throughput 3D sectioning and analytics



EBSD map of 10 mm wide sample of friction stir welded aluminium alloy. Root metal towards left, center of weld zone towards right. Sample courtesy TWI Ltd, UK. EBSD map courtesy Oxford Instruments Nanoanalysis, UK.

Chemistry and crystallography in 2D and 3D

Imaging and analytics in 3D unlock the critical data hidden deep within metal samples, enabled by focused ion beam (FIB) milling with 3D imaging, EDS and EBSD to reconstruct and navigate through features in your sample, from larger particles to the tiniest inclusion or void.

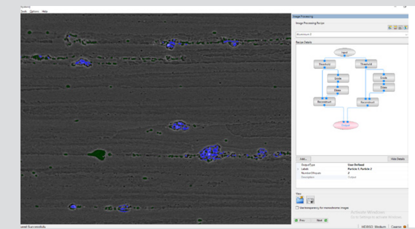
The new Crossbeam Laser accessory for massive femtosecond laser ablation offers extremely rapid sample preparation for imaging and EBSD of deeply buried features. Additional options such as time-of-flight mass spectrometry reveal the secrets of individual grains, crystals, precipitates and pores.

For ultimate 3D structural insight, correlate submicron X-ray microscopy with FIB-SEM to find "the needle in the haystack," that critical feature essential to your research.

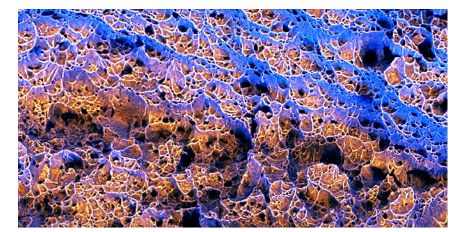
Scan to watch the full video

SmartPI: smart inclusion analysis

Inclusion analysis is critical to determining the toughness and machining characteristics of aluminum and other metals. ZEISS SmartPI software allows the rapid and easy identification, characterization and classification of inclusions in aluminum. Using an energy-dispersive X-ray spectroscopy (EDS) accessory with a best-in-class ZEISS SEM, every inclusion is scanned, imaged and analyzed automatically. Overlay chemical information over your SEM images and present them in a particle gallery for intuitive understanding of feature class and type, and report to your precise requirements and specification.

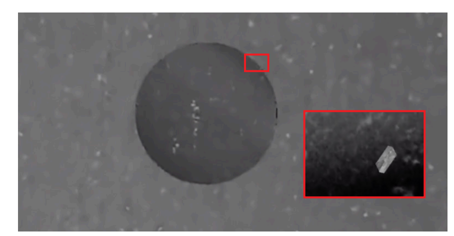


ZEISS EVO SEM with SmartPI

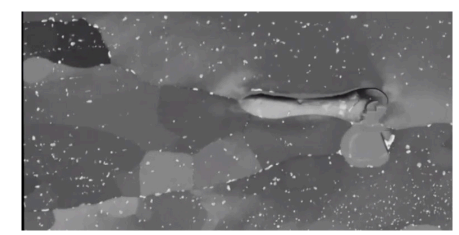


False color aluminum fracture surface in SEM

Die-cast aluminum alloy parts



Find subsurface regions of interest with non-destructive X-ray microscopy



Use FIB-SEM and Atlas 5 to automatically go to ROI uncovered by XRM to find void

X-ray microscopy: the power of non-destructive 3D imaging and crystallography

Advanced manufacturing and highly demanding duties often dictate that analysis in two dimensions is simply not enough. Researchers can now achieve fast, large-volume 3D imaging and microstructural analysis using X-ray microscopy, a bridge between micro-CT and synchrotron science right in your lab.

The ZEISS Xradia family of X-ray microscopes (XRM) achieve sub-micron 3D imaging of even large metallic structures in exceptional contrast, not possible with conventional computed tomography, with software solutions that can reconstruct and virtually explore your sample in submicron detail. The ZEISS Xradia XRM portfolio unleashes ultimate 3D resolution even for large samples.

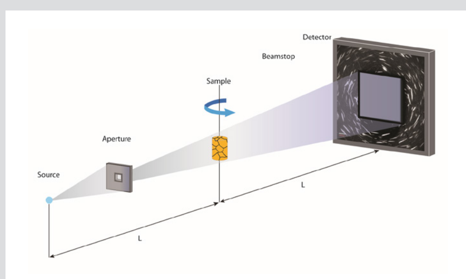
Compared to most metals, aluminum offers a low attenuation rate, meaning fewer X-rays are absorbed by it, and therefore more X-rays can be analyzed to obtain more information. High resolution, non-destructive 4D studies are made possible by resolution at a distance (RaaD) full sample imaging for in situ experiments: resolution down to 50 nm can be achieved non-destructively even on large parts. With a full picture of tomography, phase contrast, precipitates, porosity and structures, as well as crystallography, you have more insight than ever before.

3D scan of Al component produced by additive manufacturing and, inset, internal porosity imaged via X-ray microscopy

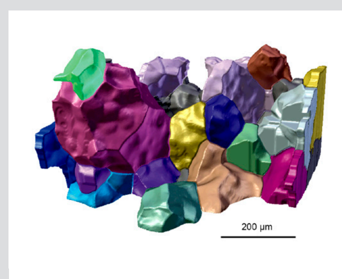
ZEISS Xradia Versa 620 X-ray microscope

LabDCT: insight in 3D

Bring synchrotron-like 3D crystallography to life in the lab with the unique Laboratory Diffraction Contrast Tomography module for ZEISS Xradia Versa. Crystals, grain orientation, precipitates and voids and their interactions are critical to performance and failure. Ultimate understanding comes from a full picture of the crystal structure of your sample. LabDCT creates and deconvolutes the diffraction patterns of transmitted X-rays to give detailed crystallography of samples, non-destructively, on large scales, even many mm, all in 3D.

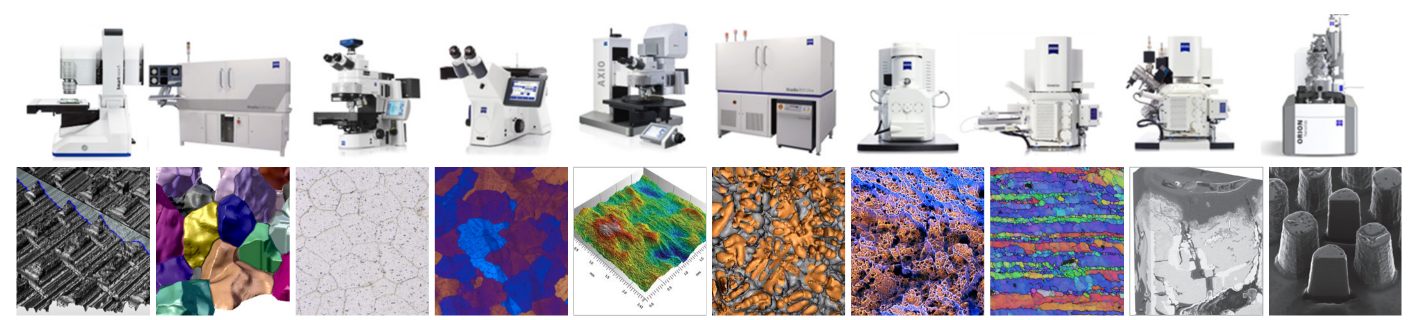


LabDCT principle



Grain morphology of a commercial aluminum alloy

Your complete toolkit for aluminum research and quality assurance



Stereo & digital LM	Sub-micron XRM	Widefield LM	Polarized LM	Confocal LM	Nanoscale XRM	C-SEM	FE-SEM	FIB-SEM	Helium Ion Microscope
1 µm	500 nm	250 nm	200 nm	200 nm	< 50 nm	< 2 nm	< 1 nm	< 1 nm	< 0.5 nm

Above:

Aluminum alloy grain structure transverse to extrusion direction, darkfield light micrograph, ZEISS Axio Imager.Z2m

Nanoscale XRM illustration, aluminum-copper eutectic alloy, courtesy of Brian Patterson, PhD, Los Alamos National Lab, USA

EBSD maps and data provided by Oxford Instruments Nanoanalysis

FIB-SEM sample and illustration, corroded magnesium alloy, courtesy Philip Withers, University of Manchester, UK

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