Connected Productivity in the Materials Lab

ZEISS ZEN core

Software Suite for Connected Microscopy in Material Laboratories

zeiss.com/zen-core

Seeing beyond

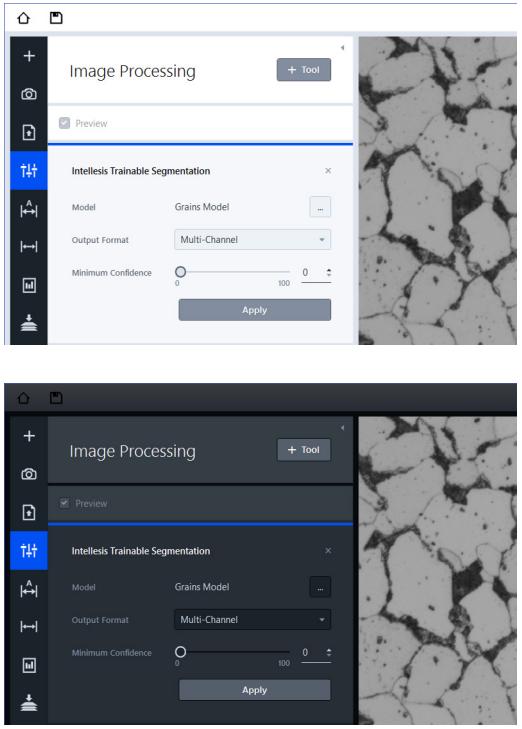
Imaging Software for Connected Microscopy in Material Laboratories

ZEN core is a powerful software suite for microscopy imaging, automated control of motorized ZEISS microscopes, and multi-modal workflows in material laboratory environments.

Use ZEN core to handle routine tasks on a wide range of ZEISS microscope and camera systems. While extracting the highest technical performance from your microscopes, ZEN core provides access to every parameter and function you might wish to optimize through an intuitive and configurable graphical interface.

Create task-specific workbenches that show only the required microscope controls on the screen. Combine these workbenches to create dedicated jobs that assist your operators through a defined flow of consecutive tasks, to ensure data repeatability in a multi-user environment.

ZEN core helps you to make your laboratory even more productive. With workflow and infrastructure solutions that connect data from different microscopes, ZEN core delivers more meaningful information in the form of correlated multi-scale and/or multi-modal characterization data. And thanks to its database connectivity features, you keep your valuable data together across instruments, laboratories, and locations.



The ZEN core user interface provides both a bright and a dark mode to meet the needs of different users and their preferred working environment.

Simpler. More Intelligent. More Integrated.

Easy to Configure. Easy to Use.

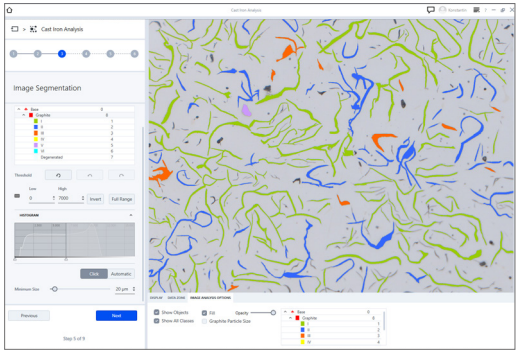
ZEN core gives you the benefit of an adaptive user interface tailored to the needs of industrial and research environments. The easy-to-follow GUI configuration accommodates tasks of all kinds and any complexity. ZEN core also offers you configurable user management, so you can specify users and user roles. Whatever their level of experience, operators will learn the software quickly. Using the ZEISS Word Add-In lets you easily create user configured report templates in MS Word®. The reporting functionality exports reports to various file formats including PDF or DOCX.

Advanced Imaging and Automated Analysis

ZEN core is the command center for automated imaging and analysis functions on compound light microscopes. By using built-in automated image acquisition routines, such as HDR or Best Image, you benefit from the consistency of an advanced and repeatable workflow. ZEN core provides automated image segmentation based on machine learning algorithms, as well as analysis functionality such as phase analysis or particle counting. Application-specific modules enhance your microscope to answer typical questions about the material structure in research and quality control.

Infrastructure Solution for the Connected Laboratory

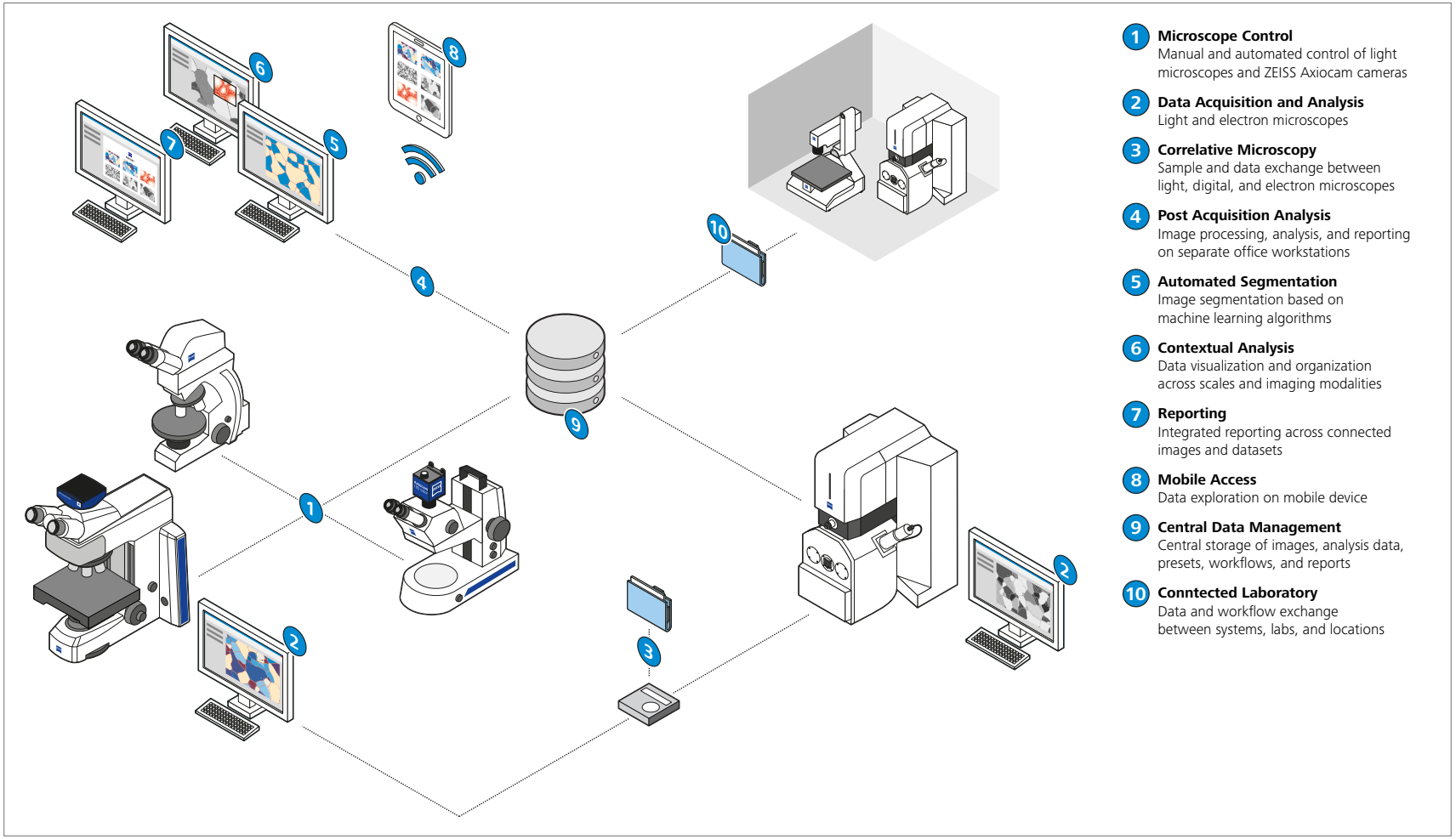
ZEN core provides the infrastructure for connected laboratory environments, linking all your ZEISS imaging and microscope solutions to a single, familiar GUI. ZEN core is also the interface to the ZEISS Axiocam camera portfolio, safeguarding an open connected laboratory architecture for 3rd party solutions. ZEN core bridges different forms of light and electron microscopy, improving productivity and multi-modal data integrity. Data management and database connectivity features help you to keep your valuable analysis data together across instruments, laboratories, and locations.



Expand Your Possibilities

One Interface for all Microscopes in a Multi-User Environment

From entry-level stereo microscopes to fully automated imaging systems, ZEN core provides a unified user interface for ZEISS microscopes and cameras. ZEN core enables the correlation of light and electron microscopy in multi-modal workflows and provides connectivity between systems, laboratories, and locations.

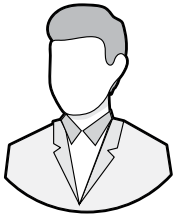


1. **Microscope Control**
   Manual and automated control of light microscopes and ZEISS Axiocam cameras
2. **Data Acquisition and Analysis**
   Light and electron microscopes
3. **Correlative Microscopy**
   Sample and data exchange between light, digital, and electron microscopes
4. **Post Acquisition Analysis**
   Image processing, analysis, and reporting on separate office workstations
5. **Automated Segmentation**
   Image segmentation based on machine learning algorithms
6. **Contextual Analysis**
   Data visualization and organization across scales and imaging modalities
7. **Reporting**
   Integrated reporting across connected images and datasets
8. **Mobile Access**
   Data exploration on mobile device
9. **Central Data Management**
   Central storage of images, analysis data, presets, workflows, and reports
10. **Conntected Laboratory**
    Data and workflow exchange between systems, labs, and locations

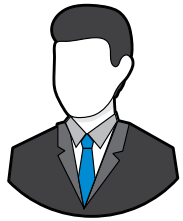
Expand Your Possibilities

User Management Designed to Assure Data Repeatability and Integrity

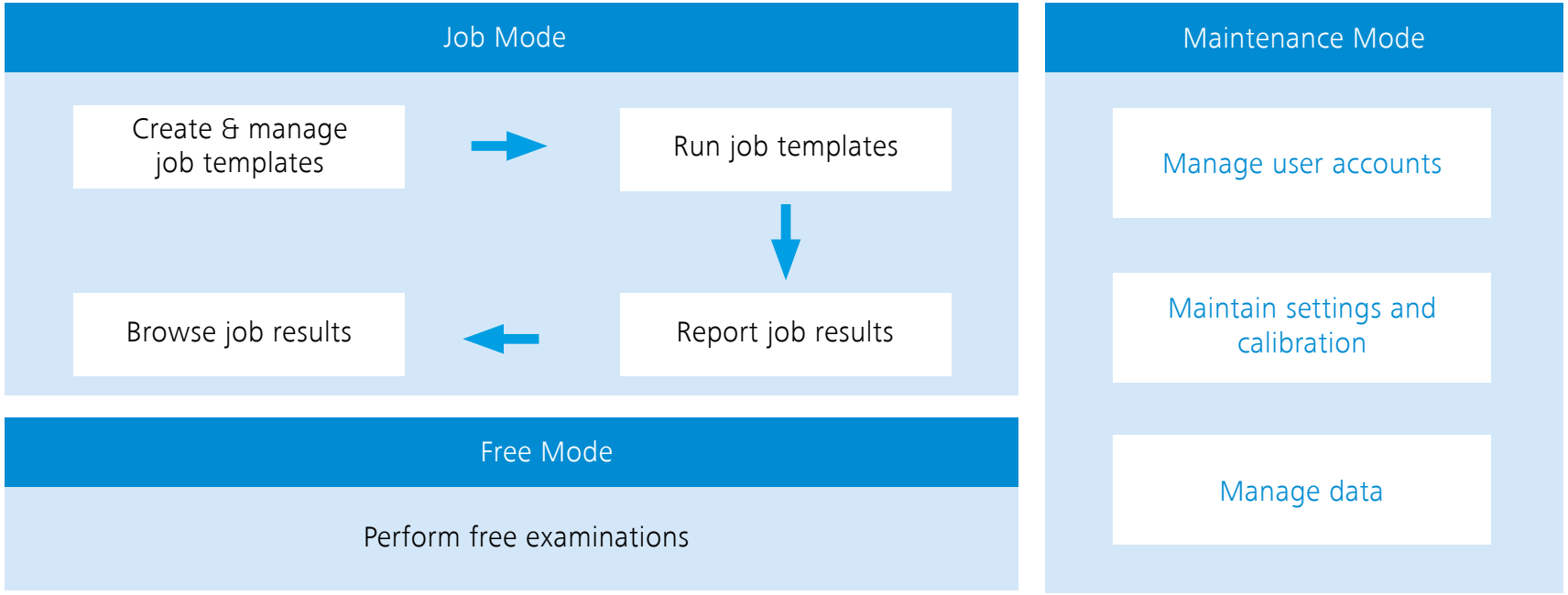
Supervisor
Experienced User



Operator
Routine User



Administrator
Lab Manager



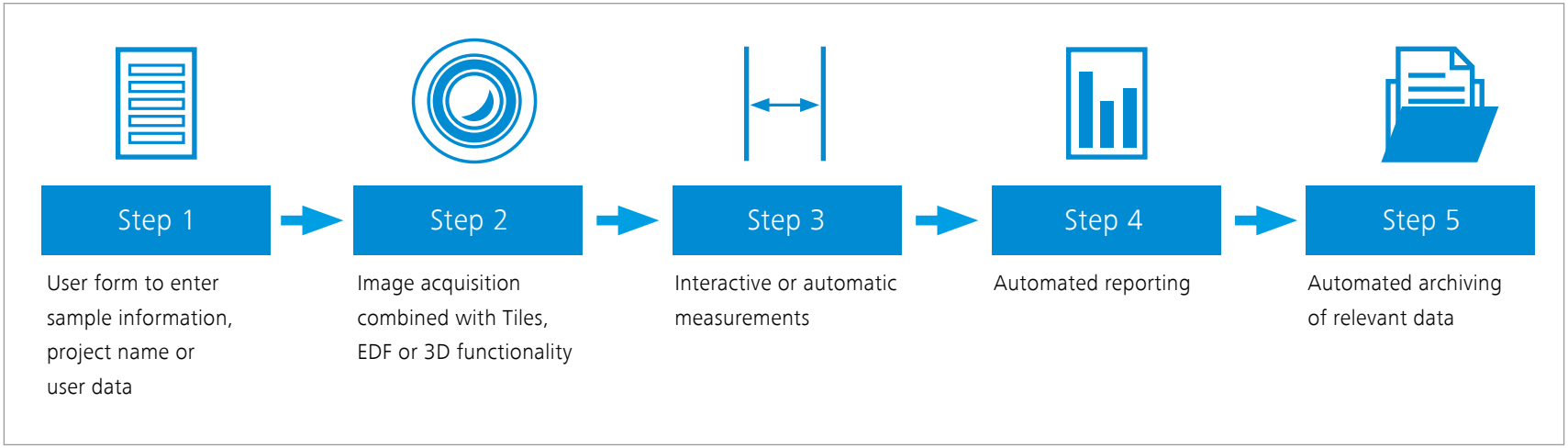
Sample configuration of multi-user management

Expand Your Possibilities

Job Mode

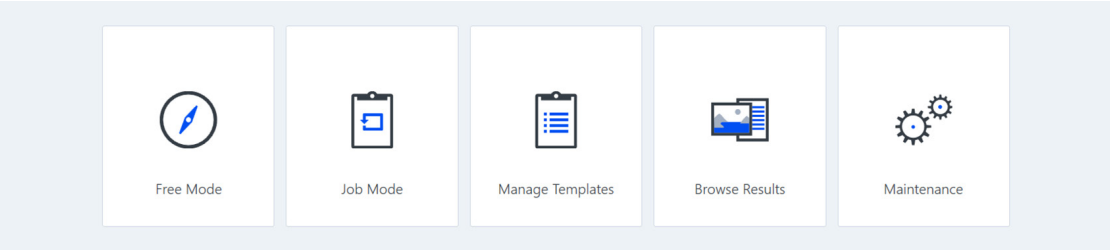
Easily set up workflows for repetitive tasks with Job Mode. Microscope parameters can be predetermined and specified as individual workbenches to guarantee reproducible results. Workbenches can be combined within a job template to set up individual workflows. Parameters within the workbenches (e.g. camera exposure time) in a job template can be locked to assure consistency in sample examination. Combine Job Mode with user management functions to assign inspection tasks to certain users and user groups.

Workflow Example



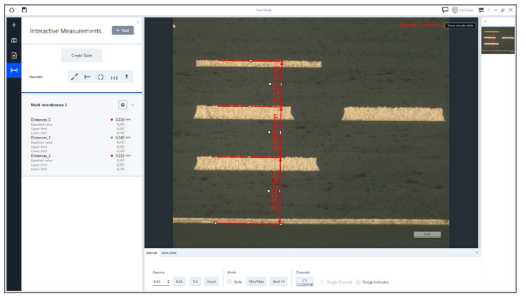
ZEISS ZEN core at Work

Standard Features

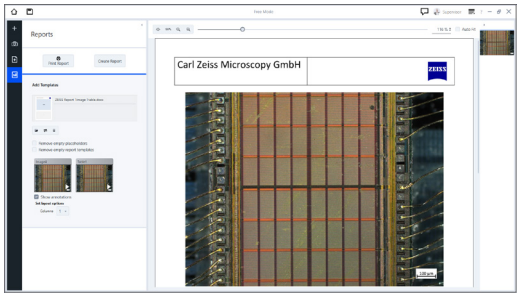


ZEN core home screen: Access to image acquisition and job functions

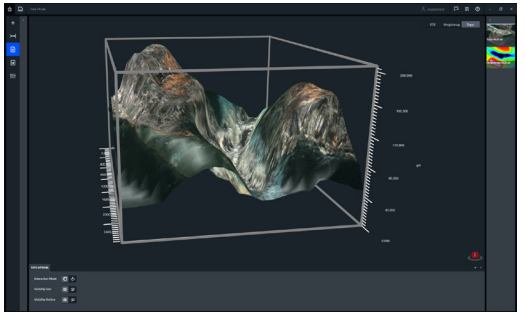
- Full operational control of ZEISS microscopes, cameras, and components
- Workbenches for repetitive application tasks
- Single and automated panorama image acquisition
- User management functionality
- High Dynamic Range (HDR) image acquisition
- Create and manage input forms
- Live image video recording
- Image and data information displayed in datazone below the image
- Best Image functionality
- Enhanced depth of field via manual focus
- Measurement functions
- Topography visualization
- Microsoft Word® reports and report templates
- Data archive for images, documents and templates
- Image export to all standard image formats such as JPG, BMP, TIFF
- Connection to ConfoMap
- Extended workflow capabilities, loop functionality



Measurement functions



Reporting template



Topography visualization

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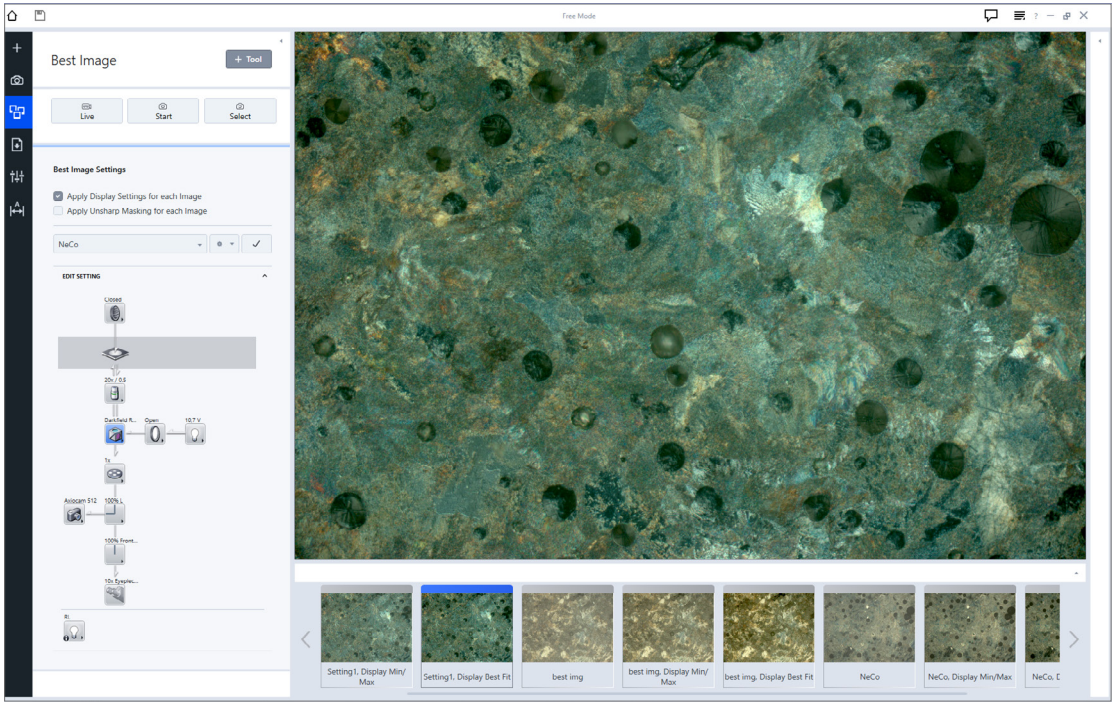
Automation for Compound Light Microscopes

Obtain results – rapidly and repeatably. ZEN core provides you with a wide range of choices for automated image acquisition:

- Best Image: assists you with the optimum microscope settings for image acquisition.
- HDR: ensures best image quality even with challenging light conditions.
- Panorama and Tiles: create stitched images in just a few clicks.
- Autofocus: automatically determine the perfect focus position for your sample.
- EDF: Automatically acquire multiple images at different focus positions and combine them to an image with enhanced depth of field.



Best Image workbench generates several images by applying different microscope presets. The user can choose the best image.

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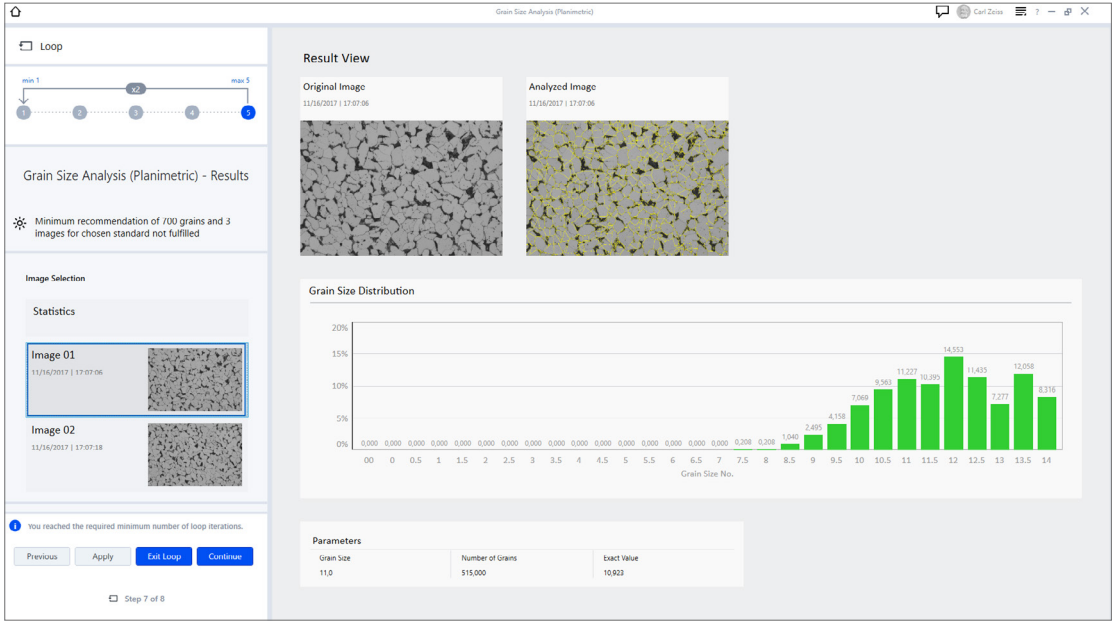
Grain Size Analysis

The size and distribution of grains are directly linked to the material properties. Quantify the crystallographic structure of your materialographic samples in accordance to international standards. Three evaluation methods allow you to characterize your material:

- **Planimetric method** for automatic grain boundary reconstruction
- **Intercept method** with a variety of different chord patterns to interactively recognize and count the intersections with grain boundaries
- **Comparison method** for manual image evaluation with comparative diagrams

Image segmentation can be performed by latest machine learning algorithms (see ZEN Intellesis).



Planimetric Grain Size Analysis – result view

Supported Standards:

- DIN EN ISO 643:2012
- ASTM E 112-13
- ASTM E 1382-97
- GB/T 6394 2017 Plate I-V

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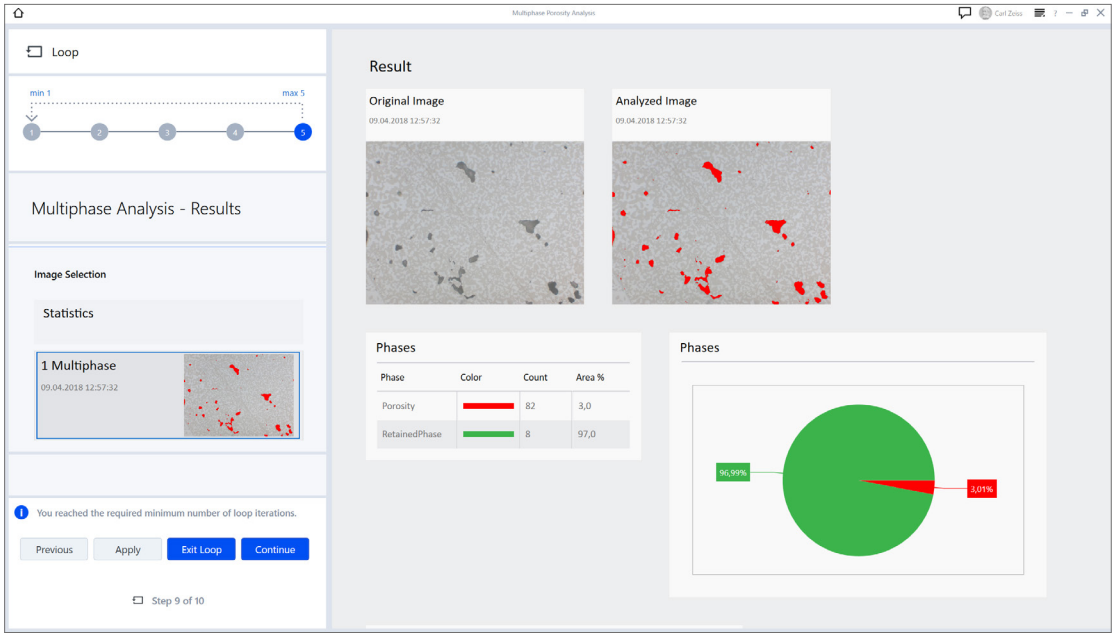
Multiphase Analysis

Any part of the material with a distinct crystal structure can be taken as a “phase”. Different phases are separated from one another by distinct boundaries. Distribution and orientation of phases affect the material properties like hardness, strength or elongation at break.

Analyze the phase distribution in your samples. Determine size, shape or orientation precisely and fully automatically. Use this distribution analysis to gain information about porosity of additive manufactured material.

Image segmentation can be performed by latest machine learning algorithms (see ZEN Intellesis).



Multiphase Analysis – result view with distribution of different phases

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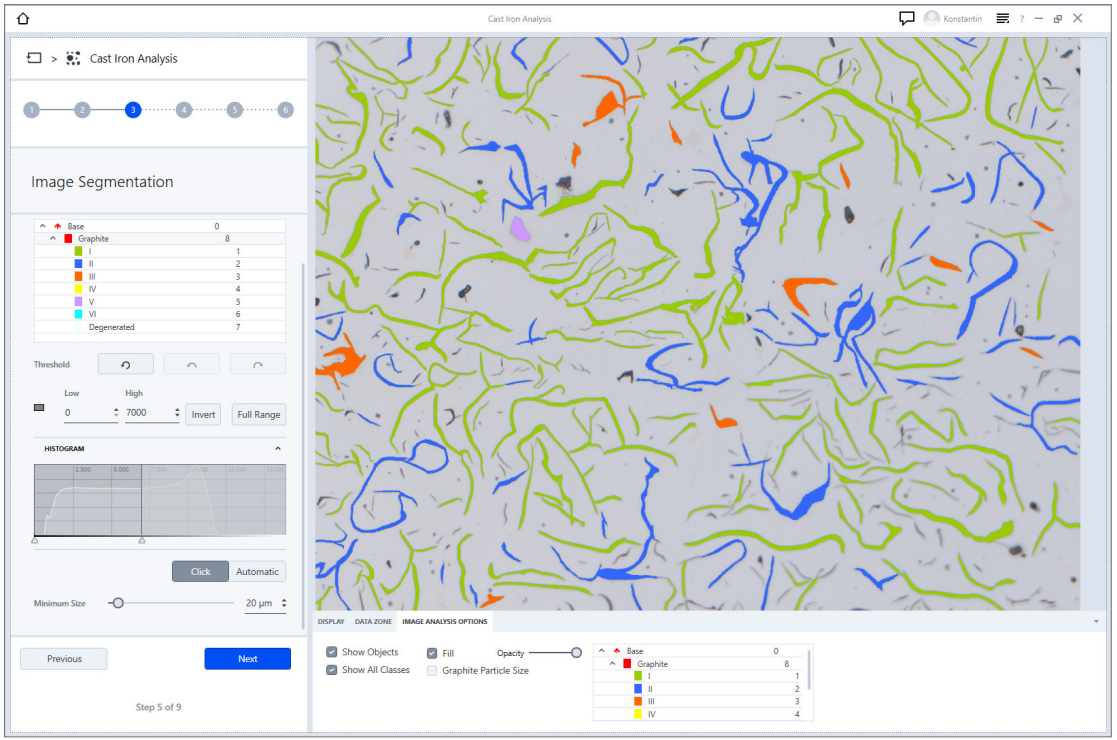
Cast Iron Analysis

Depending on process parameters and chemical composition of the material, graphite particles in cast iron can occur in different shape and distribution. This influences the mechanical properties of the material.

Analyze the shape and size of graphite particles fully automatically. Obtain the spheroid number according to DIN EN ISO 945 (2019). Determine the nodularity of vermicular graphite and examine the content of graphite particles in area percentage.



Cast Iron Analysis – image segmentation step

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Layer Thickness Measurement

Measure thickness of coatings and platings, or the depth of hardened surfaces in the cross section of a sample.

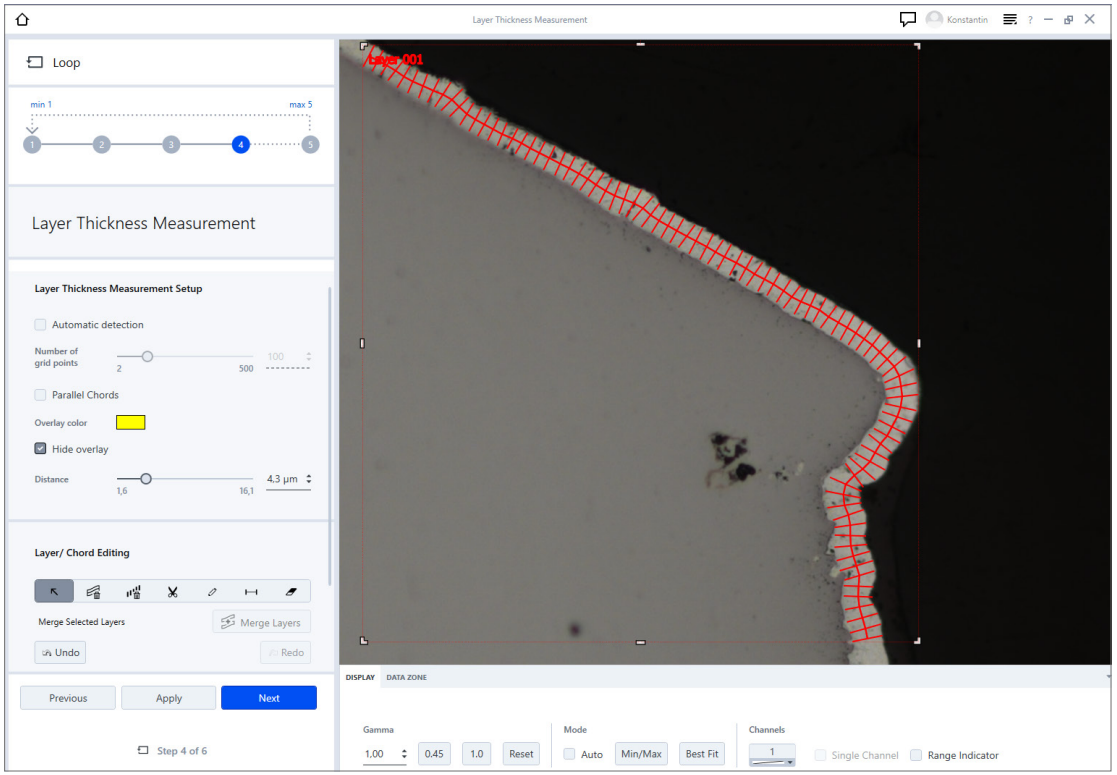
Evaluate complex layers systems either automatically or interactively. The module calculates the course of the measurement chords depending on the gradient present.

Get the results from your part in a clear report containing images, sample data and measurement values, such as the maximum and minimum chord lengths, mean, and standard deviation.

Image segmentation can be performed by latest machine learning algorithms (see ZEN Intellesis).

Supported Standards:

- DIN EN ISO 1463 - 2004
- ASTM B 487 - 2007



Layer Thickness Measurement – automatic detection of a layer

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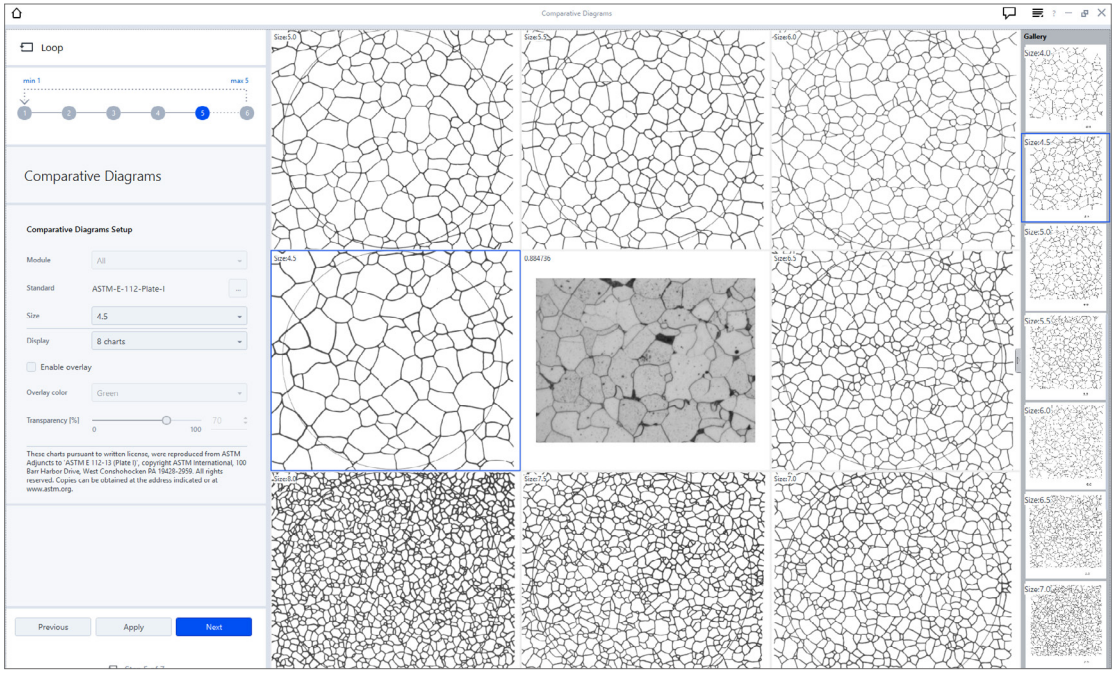
Comparative Diagrams

Make your Wall Charts digital. Compare your sample under the microscope with comparative diagrams directly on your screen. Choose between different schematic micrographs with specific characteristics. These change gradually from image to image and may relate to grain size, carbide precipitation in steel, or quality of sample preparation. The module also provides a chart series creator to design your own comparison diagrams, e.g. for pass-/fail criteria in quality control or best target preparation images for your individual material microstructures.



Comparative Diagrams: Compare the sample with standardized or customized wall charts.

Supported Standards

Grains:

DIN EN ISO 643:2012

ASTM E 112-13 Plate I-IV

GB/T 6394 2017 Plate I-IV

Graphite:

EN ISO 945-1: 2008 + Cor. 1: 2010

Non-metallic inclusion (NMI):

ASTM E45

ISO 4967

GB/T 10561

EN 10247

DIN 50602

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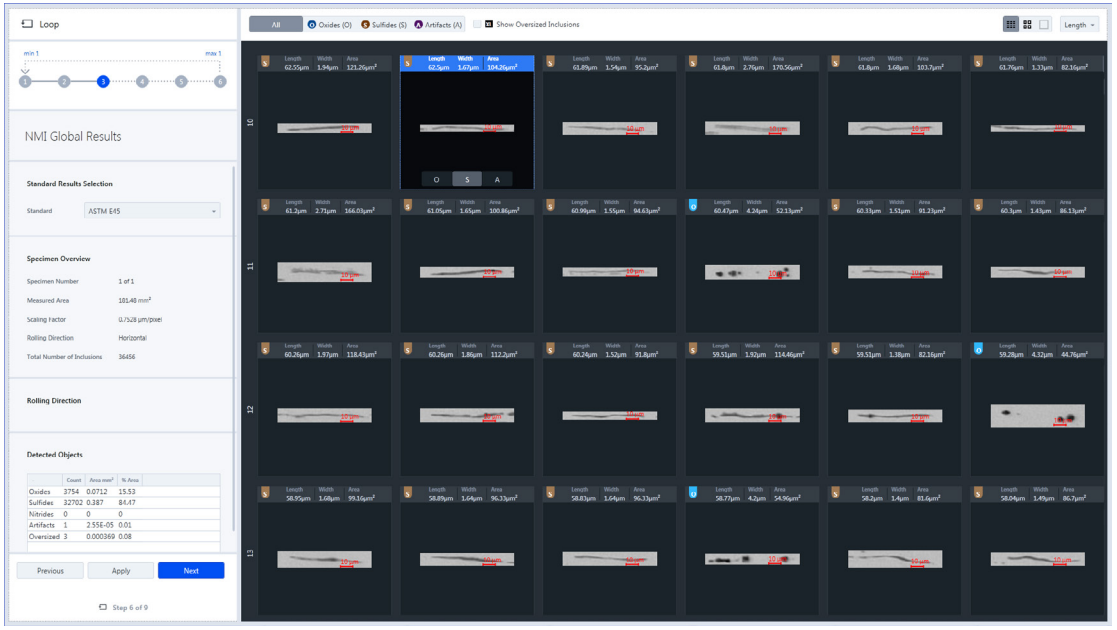
Non-Metallic Inclusion Analysis

The type and amount of non-metallic inclusions (NMI) in steels strongly affect the mechanical and physical properties of these steels.

Metallographic analysis of NMI is governed by industry standards that are supported by the modular and customizable ZEN core software which guides the user quickly and easily through the workflow, generating a report and inclusion gallery compliant with the standards.

ZEISS ZEN module Non-Metallic Inclusion Analysis confirms that manufacturing processes, grade and quality of the product meet strict specifications for impurities or defects that can cause a component to fail or impact its tensile strength, toughness and fatigue.

Powerful inspection views and automated deformation axis detection features make analysis easy, intuitive and repeatable. With additional GxP functionality, ZEN core users are able to offer their customers full traceability and data integrity in NMI analyses, meaning that grade certification is auditable, particularly advantageous for customers in regulated industries.



NMI user interface: Global Results view providing the option to toggle between the display of inclusion types oxides, sulfides, and artifacts.

Supported Standards

ASTM E45
ISO 4967
JIS G0555
GB/T 10561
EN 10247
SEP 1571
DIN 50602

ZEISS ZEN core at Work

Technical Cleanliness Analysis

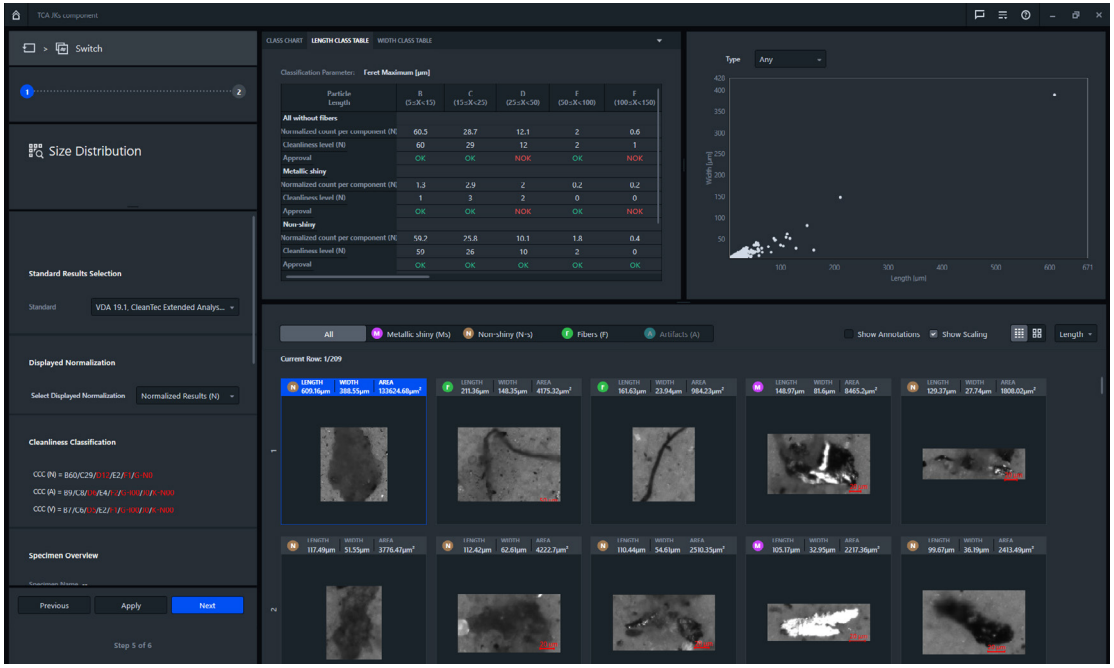
Suppliers, manufacturers and end users demand ever-increasing quality standards, so an advanced technical cleanliness program is fundamental to eradicating contamination of manufactured parts and components along the entire production process. Additionally, the major source of failure in hydraulic and oil-filled machines is based on particulate contamination. Oil analysis helps to minimize maintenance costs and improve machine uptime.

This easy-to-use software for standards-compliant cleanliness analyses enables the automated identification and classification of particles.

One-scan technology

Unlike conventional analysis methods, only one filter scan is needed to acquire both brightfield and crossed polarization image information to detect metallic particles, which dramatically speeds up not only cleanliness reporting but also the identification of contamination sources.

Being part of ZEN core, ZEISS Technical Cleanliness Analysis can be seamlessly integrated into extended analysis workflows.



Technical Cleanliness Analysis user interface: Size distribution view

Supported Standards

Technical Cleanliness:
VDA 19.1
ISO 16232

Cleanliness of medical devices in the manufacturing process:
VDI 2083

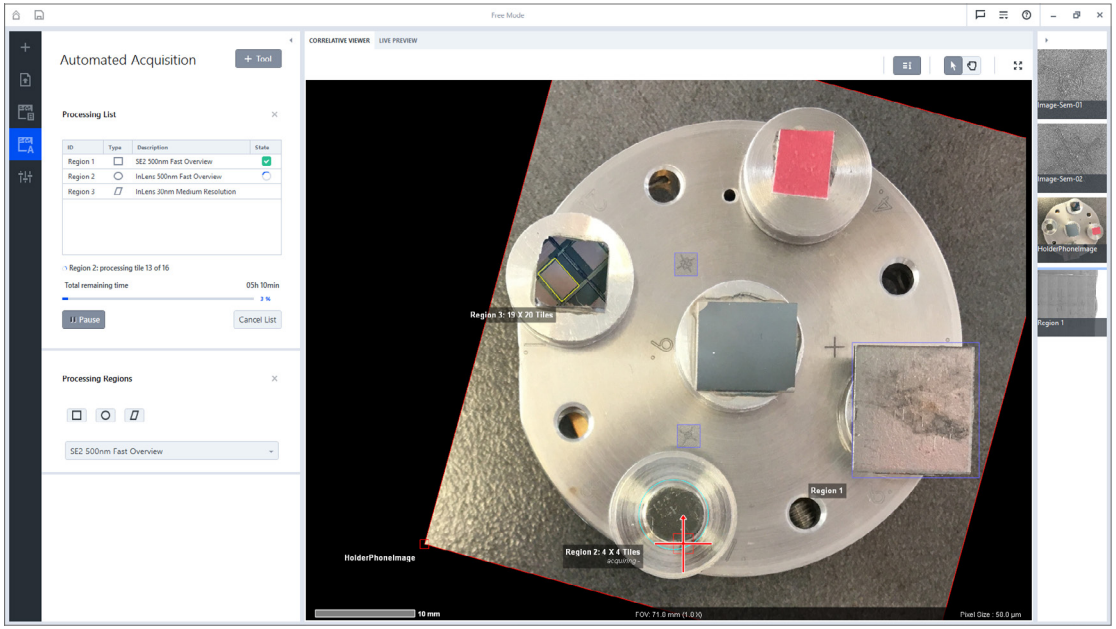
Oil Cleanliness:
ISO 4406
ISO 4007
DIN 51455
SAE AS 4059

ZEISS ZEN core at Work

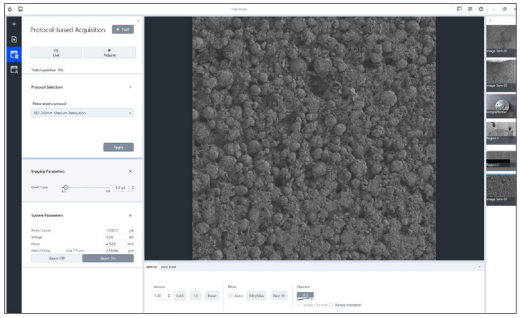
Automated Imaging for Scanning Electron Microscopes (SEM)

ZEN core helps to bridge light and electron microscopy in many ways. The SEM Automated Imaging module simplifies electron microscope operation for new users, enabling them to acquire single images, as well as tiled images of larger regions, using predefined parameters.

- Manage protocols for all necessary acquisition parameters in a central location. Choose from predefined settings or adapt them to fit your imaging needs.
- Leverage existing image data in the ZEN Connect workspace to define regions for automated SEM mosaic acquisition.
- Add all regions to the acquisition queue and record images in one session.
- Benefit from acquisition time estimates to plan when imaging will be finished.
- Verify image quality using the live preview.
- Acquire single image frames based on settings from a saved protocol. Temporarily change parameters like pixel dwell time if needed.
- Easily store and recall stage positions.
- Combine the SEM image acquisition workbench with your choice of ZEN core's image processing, analysis and reporting functions, to create easy-to-use, reproducible workflows.



Operators can define rectangular, circular or even freehand shaped regions for automated, protocol-based SEM acquisition, leveraging the ZEN Connect workspace.



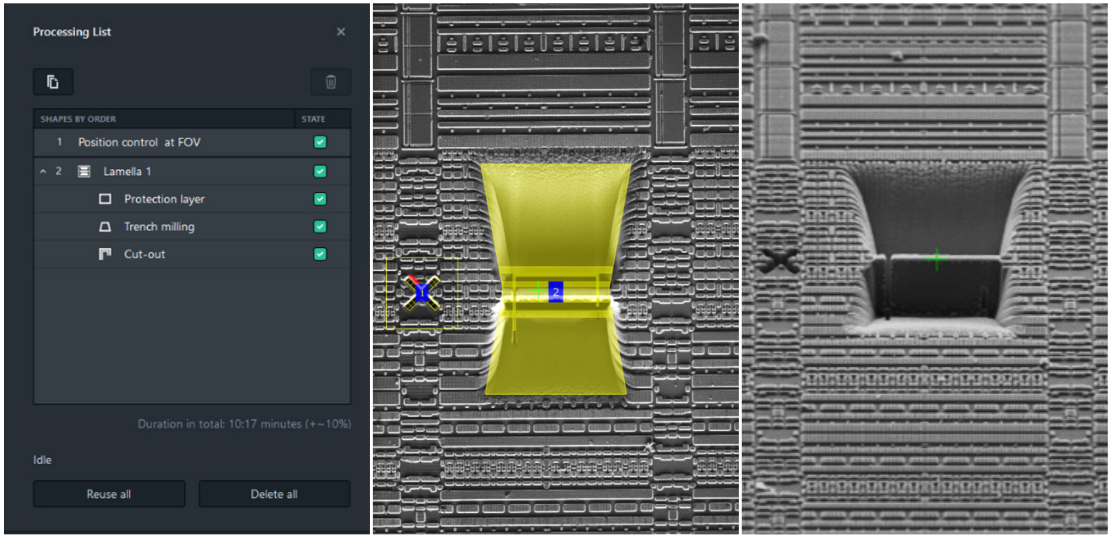
Protocol-based acquisition of single-frame images, allowing users to temporarily adjust imaging parameters

ZEISS ZEN core at Work

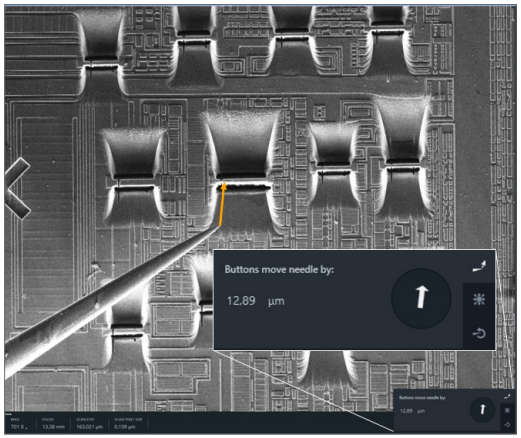
TEM Sample Preparation for ZEISS Crossbeams

ZEN core takes full control of ZEISS Crossbeam for the fast, easy and reliable preparation of samples for transmission electron microscopy (TEM) studies.

- Speed up your workflow with a task-specific workbench that shows only the controls you need.
- Run automatic routines for the preparation of single or multiple regions of interest.
- Experience ease-of-use with fully integrated micromanipulator control. Intuitively drive the manipulator needle by just clicking on SEM and FIB images.
- As a novice, enjoy high success rates from start on using guided workflows.
- Increase the productivity of your advanced TEM sample workflows for planar view and backside preparation. These include flipping of the TEM sample support grid, which in combination with ZEISS Flip Holder, is now just one mouse click away.



Automated TEM sample preparation. (left) Processing list. (center) FIB view with milling objects. (right) SEM view.



Intuitive manipulator control.

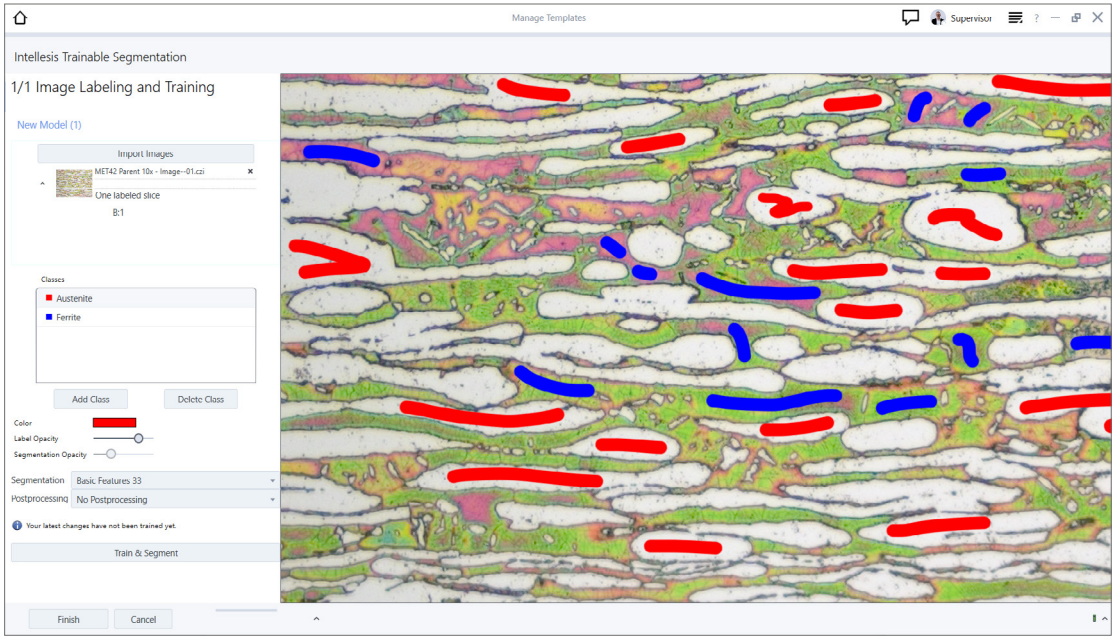
ZEISS ZEN core at Work

ZEN Intellesis: Image Segmentation by Machine Learning

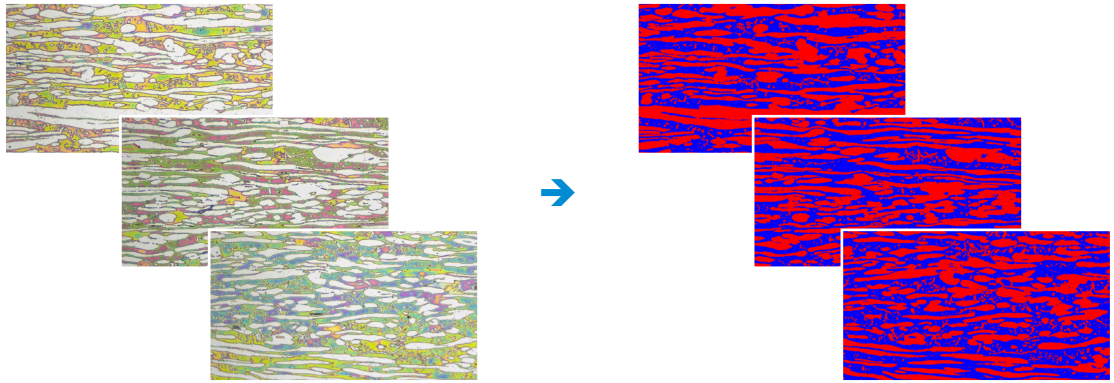
Segmentation is one of the biggest challenges faced by today's microscopists. With image segmentation using machine learning you can avoid errors and influences of user bias. ZEN Intellesis is your software module for powerful machine learning segmentation of multidimensional images including 3D datasets. You can smoothly integrate multiple imaging modalities or achieve superior segmentation on any single image.

Images that had to be processed manually can now be analyzed automatically, by training ZEN Intellesis to segment them for you, using the straightforward graphical interface. Use your expertise to train the software and let ZEN Intellesis do the tedious segmentation.

You will also benefit from saving sample preparation time, as ZEN Intellesis can adapt to your sample preparation. Reproducibility is guaranteed as the stored analysis program can be re-used sample by sample, or re-trained to handle new samples.



ZEN Intellesis user interface: The user labels a few regions just by painting them in to teach the system how to segment the image.



Once a segmentation model has been trained, it can be re-used, shared, and applied to a bundle of images.

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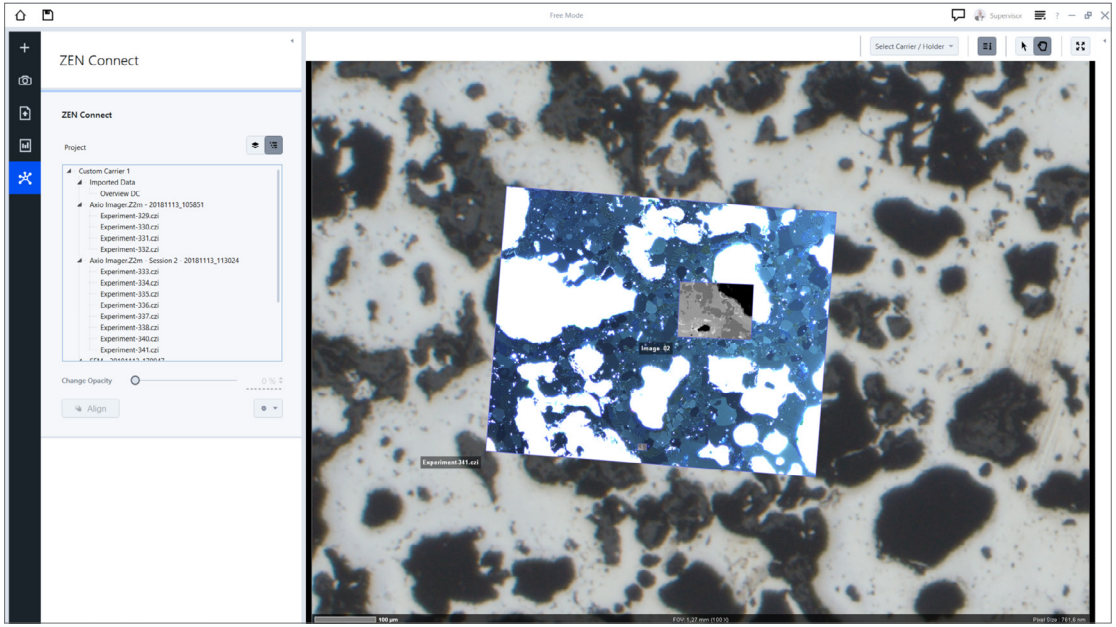
ZEN Connect: Quality Data Put in Context

Organize and visualize different microscopy images and data from the same sample in their context, all in one place. For sample-centric analysis, ZEN Connect workflows enable you to get from a quick overview image to advanced imaging with multipe modalities. The correlations between the images at different scales can be seen and easily navigated. The interdependencies of the different datasets can be stored, exported and re-used in a Client Server Database.
ZEN Connect also enables an integrated reporting across the connected images, videos, and datasets.

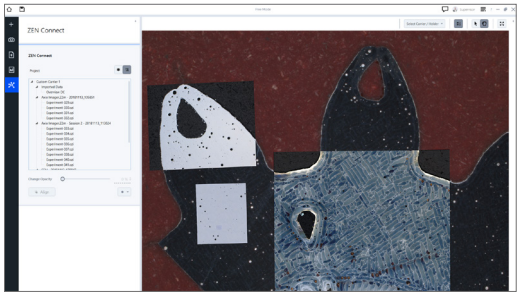
Correlative Microscopy

The ZEISS correlative microscopy interface enables you to seamlessly transfer samples between different light and/or electron microscopes, then quickly and automatically relocate regions of interest to collect maximum relevant data with minimal effort.

- Transfer samples and image data between ZEISS light and electron microscope systems
- Relocate regions of interest automatically
- Improve efficiency and throughput
- Collect the maximum relevant information
- Make well informed material decisions



ZEN Connect user interface



Additively manufactured gear wheel. Imaged on ZEISS Axio Zoom for overview and ZEISS Axio Imager for higher resolution. All images are aligned and well structured in one ZEISS ZEN Connect project. Courtesy of T. Schubert, Aalen University, Germany.

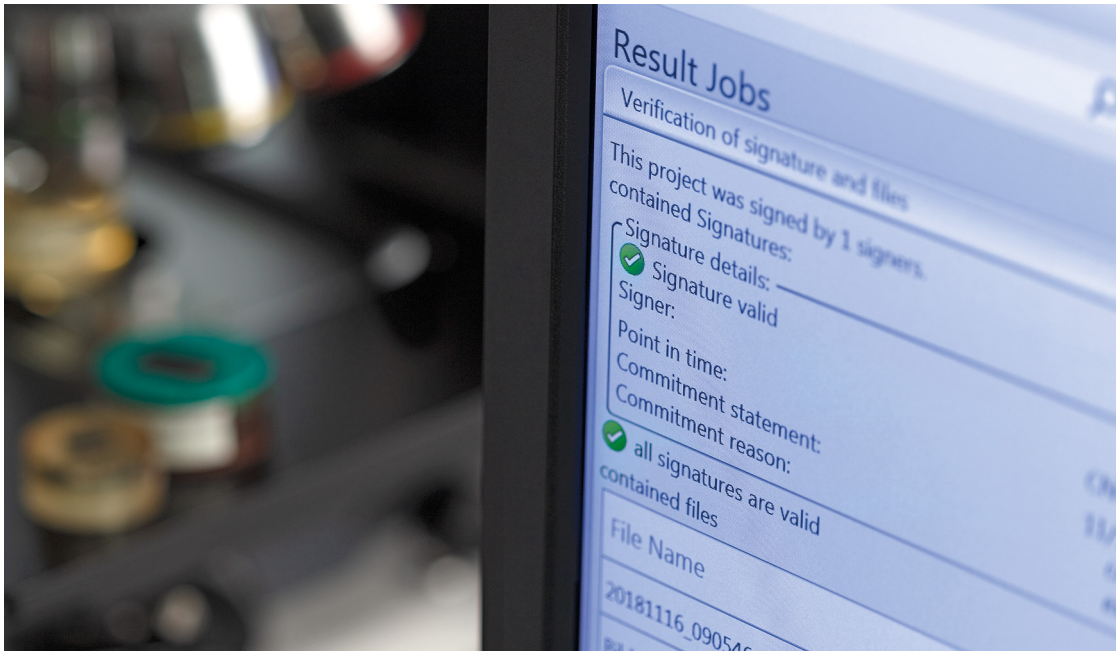
ZEISS ZEN core at Work

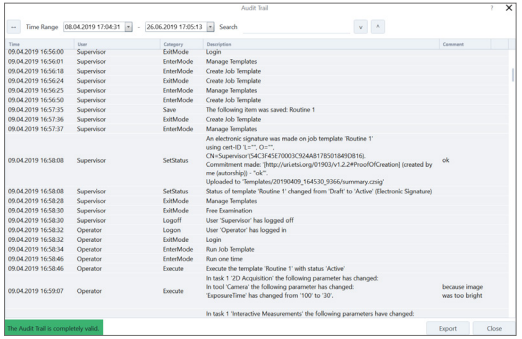
GxP Module

The GxP module enables traceable workflows through seamlessly integrated microscopy hardware and software to meet the requirements of regulated industries. Every workflow available in ZEN core can be made GxP compliant.

The GxP module helps:

- **Quality Managers** who want to guarantee reproducible results and secured processes
- **Validation Engineers** who want to be able to validate their microscopy processes
- **Lab Managers** who need to document their microscopy processes
- **IT Managers** who need backup/disaster recovery functionality, and archive/database capability
- **Pharmaceutical Companies** who need to be compliant to e.g. FDA 21 CFR Part 11





Audit Trail of all user activities

Use a variety of tools and functionalities in combination with the required qualification and validation activities to maintain GxP compliance for your images, tables, and reports:

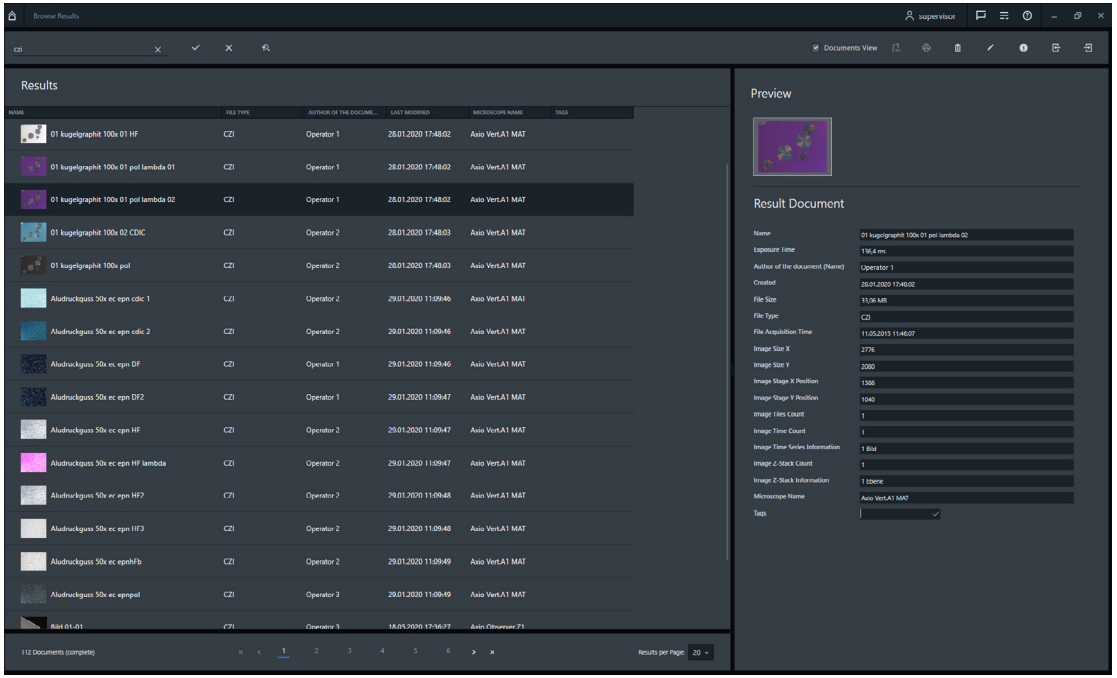
- User management
- Audit trail
- Release procedure of workflows
- Electronic signatures, incl. countersign functionality
- Checksum protection of process-critical data
- Disaster recovery
- Combination of different clients via database

ZEISS ZEN core at Work

Browse Results

Easily browse and access all results, even those generated from multiple instruments operated via ZEN core.

- Access data collected from individual systems or from multi-modal workflows.
- Store your results and templates centrally across systems, laboratories and locations.
- Organize your data through document tagging.
- Browse your assets with powerful sorting and filtering features.
- Upgrade to database and multi-user systems.



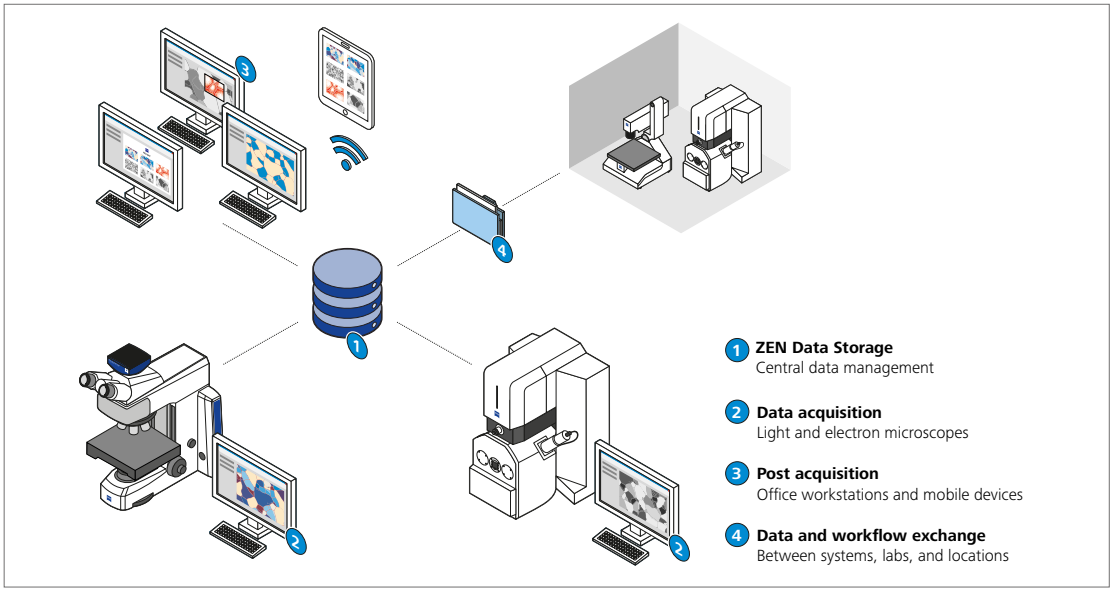
Filtering and managing your results in the browse result view of ZEN core

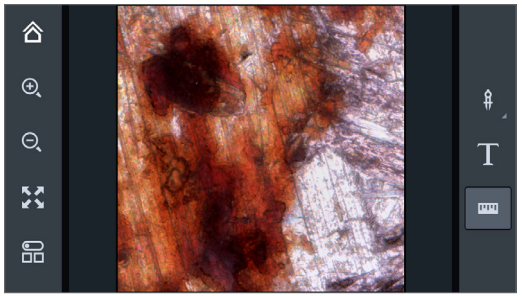
ZEISS ZEN core at Work

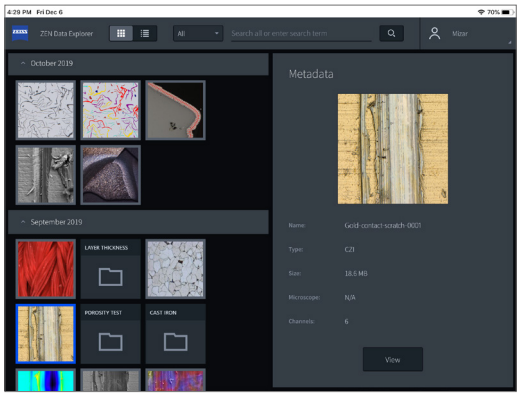
ZEN Data Storage: Central Data Management in the Connected Laboratory

As digitization continues to improve microscopic investigations, you're facing an ever-growing mass of images and data that needs to be managed, all the more so in multi-user laboratories. ZEN Data Storage enables you to separate image and data acquisition from post-acquisition works, making everyone in the lab work more efficiently in a number of ways:

- Experts and non-experts alike can share instrument presets, workflows, data and reports with ease.
- Access to all data from different microscope systems as well as mobile and desktop devices is a given – from different locations, too.
- Access any ZEN Data Storage content with ZEN Data Explorer, a hybrid app for iOS and Android, to browse, view, and annotate images and ZEN core job results.
- Automatically upload existing image collections, including third-party images.
- Your analyses are quality assured and reproducible.
- With effortless correlation of data from different microscopes, you can perform multi-modal workflows and reap maximum information from your samples.
- You'll also help your IT department implement security and backups.







ZEN Data Explorer: The web-based app, included in the ZEN Data Storage server package, allows to browse, view, and annotate images on smartphones and tablet devices.

Your Flexible Choice of Components

Select Your Modules According to Your Requirements

Generic Functions	ZEN starter	ZEN analyzer	ZEN core	Description
Microscope Control			●	Control of microscope and devices from software
Camera Control	●		●	Control of cameras from software
Workbenches	Generic work-benches	Workbenches depending on functional modules	Workbenches depending on functional modules	Depending on the functionality and modules, the respective workbenches are available
Basic Measurement	●	●	●	Basic functions for interactive measurement
Topo View	●	●	●	3D visualization of topography images and hightmap representation
Database Interface	●	●	●	Basic interface for storing data in databases
Reporting	●	●	●	Creation of reports containing detailed information
Report Template Creator (MS Word® Add-In)		●	●	Software to create report templates using MS Word®
ZEN Connect Entry	●	●	●	Interactive acquisition and contextual display of images in single- and multi-instrument workflows
Connection to APEER	●	●	●	Connection to APEER, a cloud-based platform to share, run, and customize microscopy workflows
CAD Import		●	●	Import CAD data to create overlay images

Functional Modules	ZEN starter	ZEN analyzer	ZEN core	Description
Manual Extended Focus	●		●	Manually acquire multiple images at different focus positions and combine them to an image with a greater depth of field
Panorama	●		●	Manual acquisition of high resolution images; automated acquisition and stitching functionality on coded and non-coded stages
Measurement	○	●	●	Extended functionality of interactive measurement
Qual Data Export		○	○	Create measurement files for Database like ZEISS PiWeb or qs-STAT.
Online Measurement	○		○	Measurement of areas and non-area values in the live image
Image Analysis	○	○	○	Creation of automatic measurement programs
Motorized Extended Focus			○	Automatically acquire multiple images at different focus positions and combine them to create an image with a greater depth of field
Advanced Processing & Analysis		○	○	Add hierarchical measurements and more processing to your image analysis

● Included ○ Optional

Your Flexible Choice of Components

Functional Modules	ZEN starter	ZEN analyzer	ZEN core	Description
Tiles & Positions			O	Record exact, highly resolved images of large samples by automatically scanning pre-defined areas
Autofocus			O	Determine the focus position of your sample
Linkam (Hardware Control)			O	Interface to control Linkam heating- and cooling stages
Macro Environment		O	O	Use Python programming language to generate customer specific macros
LM-EM Correlative Microscopy Materials			O	Correlative Microscopy module for image acquisition and correlation on light and electron microscopes.
GxP		O	O	Insure traceability and accouability of workflows (precondition for 21 CFR Part 11 compliance)
ZEN Intellesis		O	O	Automated image segmentation based on machine learning algorithms
ZEN Connect	O	O	O	Extend ZEN Connect functionality to correlative workspaces
ZEN Data Storage Client	O	O	O	Seamlessly connect to ZEN Data Storage Server for central storage of documents and templates
Thirt-party Import	O	O	O	Import 3rd-party microscopy images and metadata into ZEN core
Grain Size Analysis		O	O	Determine grain sizes in three different methods according to international standards
Cast Iron Analysis		O	O	Analyze form, size and distribution of graphite particles in cast iron
Multiphase Analysis		O	O	Automated measurement of particle size and area content of multiphase samples, also evaluation of porosity
Comparative Diagrams		O	O	Compare micrographs with standardized or customizable comparative charts (Wall Charts)
Layer Thickness Measurement		O	O	Automated or interactive thickness measurement of different layers
Non-Metallic Inclusion Analysis		O	O	Automated imaging, classification and reporting of non-metallic inclusions in steel
Technical Cleanliness Analysis		O	O	Automated identification and classification of particles compliant to cleanliness standards

● Included O Optional

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