Technical paper

Automated microscopy solutions from ZEISS.
The one-click quality assurance.

ZEISS Industrial Microscopy Series

Connected microscopy.
Accelerate decision-making.

ZEISS

Seeing beyond

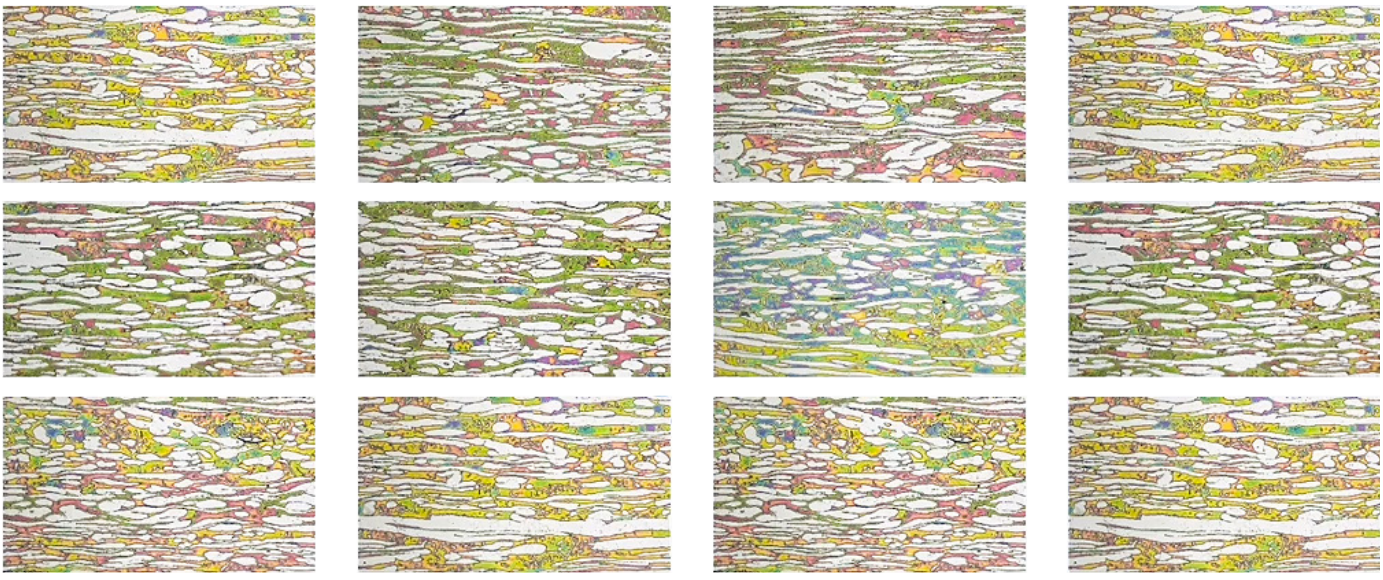
Automated microscopy: Artificial intelligence realizes fully automated routine workflows

ZEISS has powered innovation in the field of microscopy for 175 years, with a product portfolio comprising light, confocal, electron, and X-ray microscopes. Key applications in industrial settings include failure analysis and metallography, optical inspection and metrology, technical cleanliness, and surface characterization. These boost productivity and reliability by analyzing critical properties of the internal material structure, creating fast and repeatable images for accurate decision-making, avoiding particle contamination, and identifying roughness via 3D topography. What makes ZEISS industrial microscopy unique is the software suite "ZEN core," which connects all these devices, deploys sophisticated artificial intelligence (AI), and handles tasks ranging from image acquisition and segmentation to the generation of measurements and reports. Now that the all-important image segmentation can be fully automated with AI, previously manual tasks can be completed entirely automatically.

From manual to automated: reimagining routine workflows

Thanks to AI-backed automated microscopy, routine workflows can be completed in a revolutionary new way that was simply impossible just a few years ago. The image segmentation process, which involves tasks such as sorting the different phases of a microscopy image by color and accurately identifying the percentage of the image they each cover, provides the perfect example: Prior to the development of machine learning, this proved an insurmountable challenge for computers as they were unable to reliably differentiate between phases. That meant the images had to be colored in manually so as to provide the basis for further analysis, and this tedious, unreliable, and non-reproducible work was associated with highly variable results between different users.

Then there is the question of feasibility within mass production, as hundreds or thousands of images may each require painstaking checks – indeed, one user analyzes some 20,000 images daily. Even if this could somehow be realized through a manual approach, operators would be forced to start from scratch every day as any fresh knowledge would be lost. This is exactly where AI excels, as it uses machine learning to establish routine workflows that reliably deliver speedy and reproducible results.



Manual analysis of multiple microscopy images once presented a dizzying challenge

Automated Workflow

With Software Suite ZEN core

The ZEISS automated microscopy workflow combines five stages in one

1 Input

2 Image Acquisition: OAD Programming & Acquisition Modules

3 Image Segmentation: APEER ML (Deep Learning)

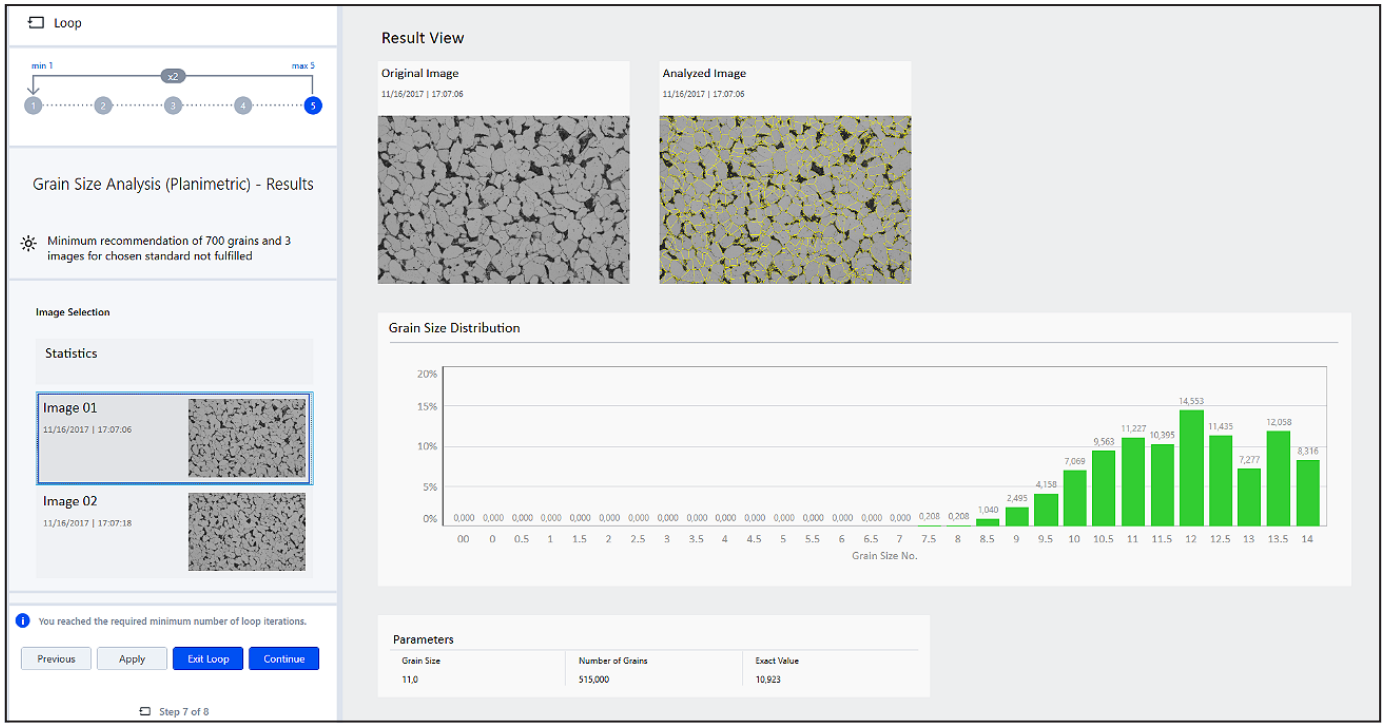
4 Measurement: ZEN Analysis Modules

5 Report: ZEN core report

Introducing Automated Microscopy from ZEISS

All steps in the microscopy process have now been united in a consolidated workflow known as Automated Microscopy from ZEISS, which is inspired by the company's commitment to solving customer problems in an efficient and sustainable manner. From initial data input to image acquisition and segmentation, and from the generation of measurements to the compilation of reports, the ZEISS ZEN core software suite provides a one-click microscopy solution for a reliable, reproducible, and of course fully automated process.

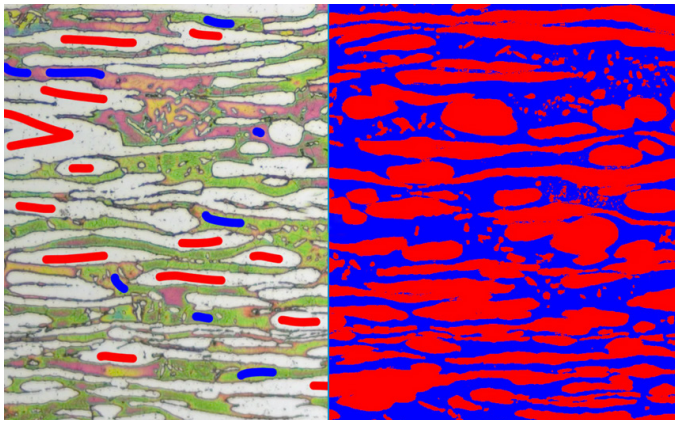
As the standard software for each of the steps in this automated workflow, it features a number of different modules for image acquisition in particular. These address issues such as the capturing of large-scale images, the positioning of images at predefined points, the handling of tiles and positions, the use of auto-focus, and the undertaking of measurements and reports. ZEISS even enables the creation of scripts for implementing all the functions featured in the image acquisition modules: Based on the Python programming language, these scripts make it possible to realize highly complex acquisition workflows including feedback and nesting. Once the relevant images have been acquired, these can be processed with the help of AI for swift and accurate recognition of objects.



The fully automated workflow in ZEISS ZEN core even extends to the compilation of reports

AI-driven image segmentation underpins automation

Image segmentation is a critical process that may require deep learning in order for the system to successfully deal with varying samples and image conditions while guaranteeing robust detection. Though this may sound complex at first, the APEER platform created by ZEISS provides an easy means of segmenting images and training neural networks – even for users who do not possess expert knowledge of AI. As the image below shows, merely coloring in a few regions is often enough to teach the system how the image should be segmented. This is another area in which the benefits of connectivity are felt, as the final trained model is always available to download from the cloud and can be integrated directly into the ZEISS ZEN core workflow. Since certain of its customers also demand support beyond the scope of the standard software, ZEISS has formed a dedicated service team called Solutions Lab: Composed entirely of data scientists, this expert unit helps customers create new workflows or even builds entire workflows on their behalf. In the following section, we will explore how the medical implant manufacturer Smith & Nephew benefits from a ZEISS automated workflow.



Left: original image during the system teaching stage; right: other half of image after segmentation via AI

Real-world productivity benefits of automated microscopy

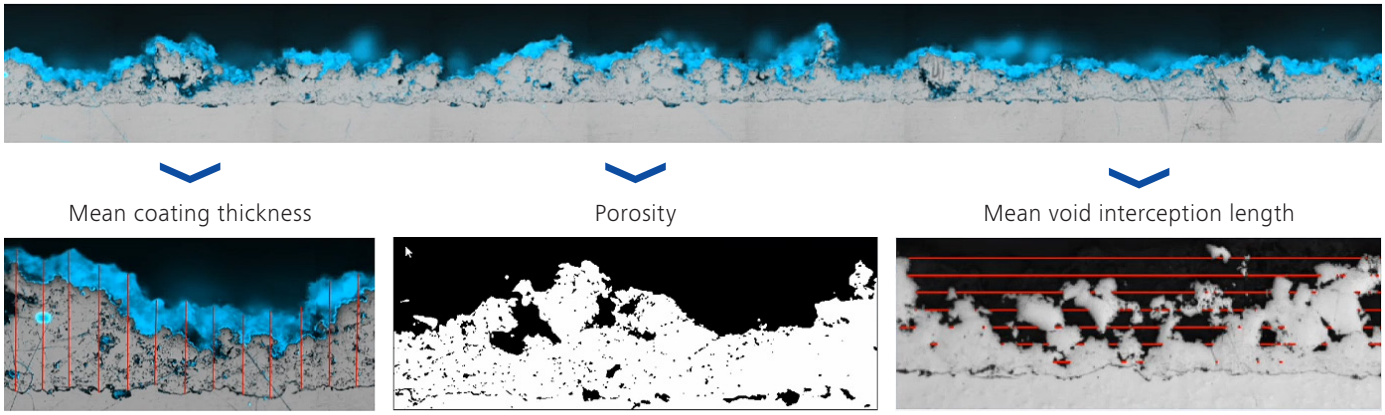
Smith & Nephew is a manufacturer of knee implants, which must feature a highly porous surface in order to grow together with the surrounding tissue. The company therefore needs to evaluate the quality of its porous coatings based on microscopy images in accordance with the corresponding medical standard ASTM F1854. This requires the measurement of the porosity and mean void interception length, the evaluation of the mean coating thickness, and the computation of various statistics including mean values, roughness, and confidence intervals.

While a manual approach would require a substantial amount of complex, repetitive, inefficient, and potentially inaccurate intervention, such as the setting of equidistant measuring lines for the evaluation of the mean coating thickness, ZEISS ZEN core software enables manufacturers like Smith & Nephew to enjoy all the benefits of an automated workflow. The user simply has to place the sample under the microscope, click the Start button in the software, and sit back as this all-in-one solution handles all the work in a matter of minutes. Not only is this fast automated workflow fully reproducible, it does not require any manual intervention and does not generate any errors.

Automation for all routine workflows and microscopes

Automated workflows can complete a wide variety of additional critical tasks that are extremely challenging if performed manually, such as corrosion scale mapping, the detection of impurities or inclusions, and porosity analysis in ceramics. They can be used for light microscopes, scanning electron microscopes, and indeed all microscope systems from ZEISS – helping you upgrade your processes no matter what hardware you may be using. Automated measurement and AI-based applications can of course be crafted with existing data. In this way, the ZEN core software suite combines the existing ZEISS portfolio with AI to take your microscopy workflows to a whole new level of productivity.

Evaluation of Porous Coatings on Medical Implants (ASTM F1854)



Connectivity for smoother operations

How does connectivity between microscopes benefit real-world processes? Primarily because manufacturers often rely on multiple tools to obtain the results they need: For example, you may start with a light microscope to detect defects before using an electron microscope for in-depth analysis and to mark areas of interest. Connectivity makes it possible to automatically relocate these areas of interest, which is extremely helpful as the manner in which different tools display features in a given area may vary considerably. On top of this, the central storage of data enables easy integration of additional departments into the process as required – no matter where they are located. And with these connectivity benefits serving to establish fully automated routine workflows supported by AI, customers can enjoy maximum productivity via adapted and streamlined processes.

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