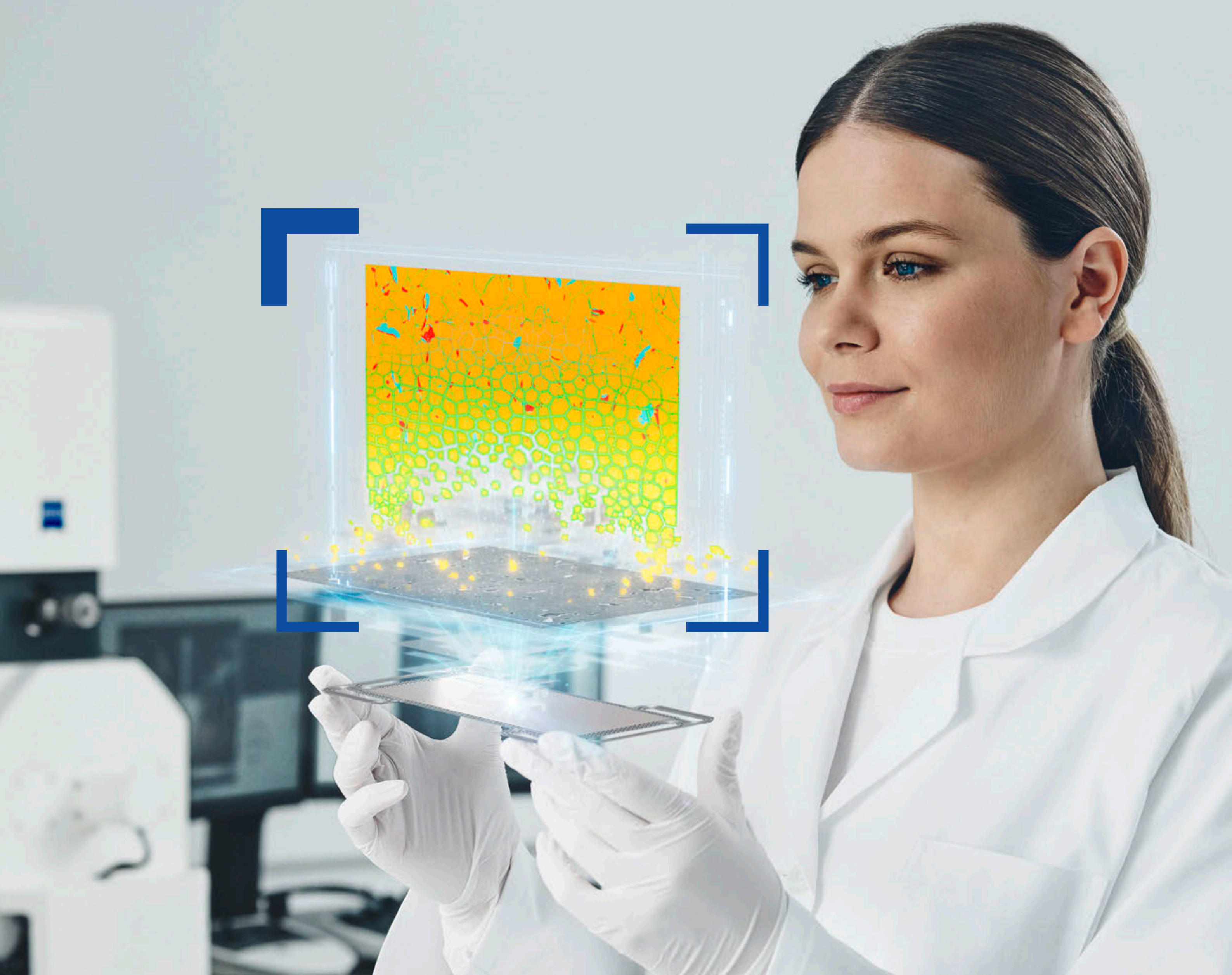
Materials get complex. Analysis gets simple.

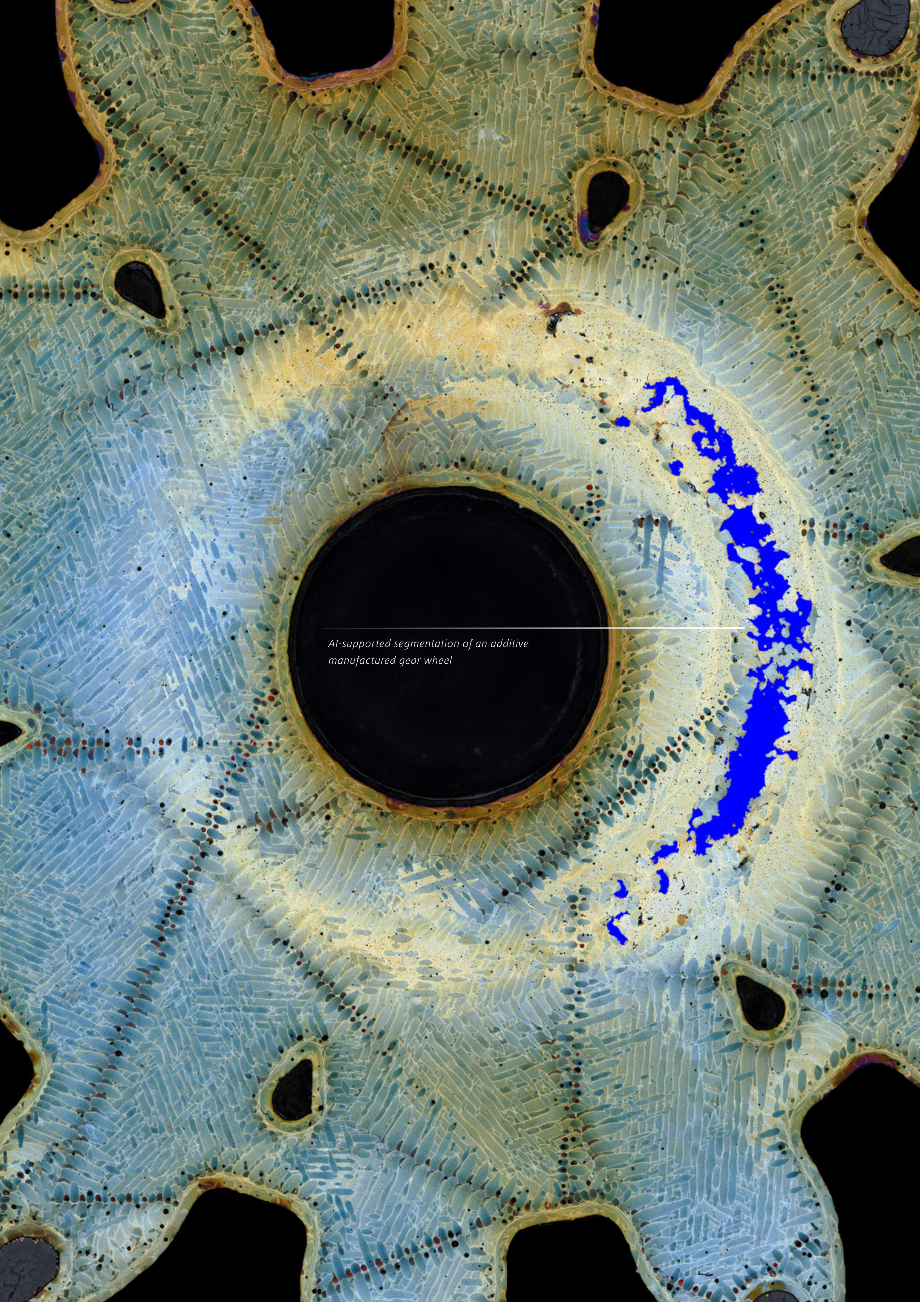


ZEISS Materialography Solutions

ZEISS

Seeing beyond

zeiss.com



AI-supported segmentation of an additive manufactured gear wheel

Mastering complexity

With microscopy solutions from ZEISS

Tasks in materialography are constantly changing and performance requirements are increasing. Components are becoming more complex, coatings ever thinner. Miniaturisation in electronics is progressing. New composite materials are being used especially in lightweight construction. Sustainable materials and additive manufactured components pose particular challenges in terms of material characterisation. At the same time, error tolerances are decreasing, making more precise analyses necessary.

Materials testing laboratories have to keep pace with these developments. At the same time, they are under increasing time pressure. ZEISS offers materialographers an unrivalled depth of microscopes, software and services to effectively solve their testing tasks. In addition, ZEISS microscopy solutions make it particularly easy for all users, because thanks to deep learning algorithms, results are more reliable, more accurate and available faster than ever before.

Materials testing in a time of change

Composite materials
Composite materials continue to grow, especially in lightweight construction. The interfaces between the bonded materials are often critical areas. Therefore, these must be checked particularly carefully.

Sustainable materials
For reasons of sustainability, for example, metals are increasingly being recycled or environmentally harmful materials are being replaced by alternatives. Materialography helps to ensure the integrity of sustainable materials.

Specific metals and alloys
The increasingly sophisticated use of special metals or alloys makes it possible to find the optimum compromise between strength and weight for each component. In this context, materialography has the task of analysing the characteristic properties of specific materials.

Miniaturised conductor paths
Miniaturisation in electronics continues to progress. With the right high-resolution microscopes, ever finer structures can be inspected quickly and reliably.

Additive manufacturing
The new possibilities of additive manufacturing are accompanied by new typical component defects. ZEISS Microscopy Solutions help materialographers to inspect 3D printed materials, analyse defects in additive manufactured components and determine the causes of defects.

Flawless and efficient microscopy
From sample to result

In materialography, meaningful microscopy results are only guaranteed if the preceding process steps have also been carried out without errors. ZEISS provides suitable microscopes to make the entire analysis process reliable and efficient: from sample extraction and preparation to image acquisition, image processing and evaluation.

Microscopy process

Cut the sample › Fix the sample › Grinding / polishing › Etching › Microscopy (image acquisition, processing and evaluation)

Microscopes exemplary

Stemi 508

Stereo microscope with 8:1 zoom

Resolution: 1 µm

Axioscope 5

Semi-motorised light microscope

Resolution: 0,7 µm

Axio Imager 2

Microscope system for automated material analysis

Resolution: 250 nm

EVO

Scanning electron microscope for high-resolution imaging and element characterisation

Resolution: 2 nm

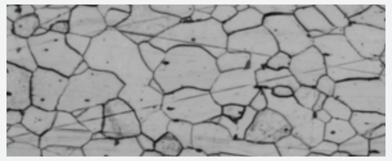
CrystalCT

X-ray microscope for non-destructive 3D imaging

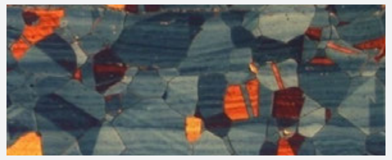
3D-Resolution: 40 nm

This becomes visible

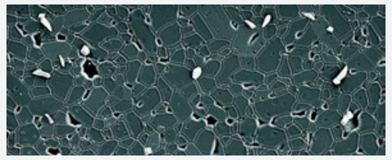
Metal surface at 24x magnification



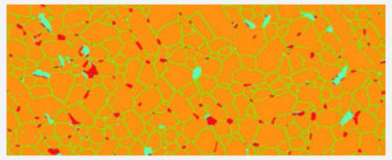
The bright field contrast image shows scratches, stains, deformations and cracks in a perforated tensile sample



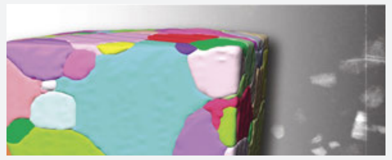
Polarisation contrast image for testing the etching process



Dark-field contrast image of a Fosterit coating



Automatic image segmentation with ZEISS ZEN core



3D visualisation of the crystal structure of titanium

Exemplary microscopy programme for material labs

Comprehensive, reliable, supportive

01 | Light microscopy

Checking the sample
Stereo microscopes
ZEISS Stemi 305/508

Repeated sample analyses, topography
Automated digital microscope
ZEISS Smartzoom 5

Routine tasks in the materials laboratory
Reflected light microscope
ZEISS Axioscope

Large and heavy samples
Inverted microscope
ZEISS Axiovert 5/7

Large sample fields, topography
Stereo zoom microscope
ZEISS Axio Zoom.V16

Automated material analysis
Fully motorized microscope system
ZEISS Axio Imager Z2m

02 Scanning electron microscopy (SEM)

Modular electron microscopy
Scanning electron microscope
ZEISS EVO product family

High quality imaging
Field emission scanning electron microscope
ZEISS Sigma product family

03 X-ray microscopy

Non-destructive 3D X-ray imaging
High-resolution X-ray microscope
ZEISS CrystalCT

04 Further ZEISS technology for material analysis

Non-destructive 3D quality inspection
Industrial computer tomograph
ZEISS METROTOM product family

Optical 3D measurements of strain, deformation and displacement (e.g. tensile test)
3D camera measuring system ZEISS ARAMIS

Your control centre for all tasks

The ZEISS ZEN core software

ZEISS ZEN core is the standardised solution for imaging, segmentation, analysis and data connectivity in your materials laboratory or company. Because the user interface can be configured according to the task at hand, even inexperienced users can operate the software easily and safely. Thanks to deep learning, ZEN core largely automates time-consuming manual work steps such as segmentation. The simple correlation of light, digital and electron microscopy enables a deeper understanding of microstructure and failure analysis. Several laboratory locations can be networked with each other via ZEISS ZEN core.

With ZEISS ZEN core, different microscope types and laboratory locations can be networked with each other.

Different microscopes – one correlated evaluation

In many applications, it makes sense to analyse the same sample with both an optical and an electron microscope. The different magnification levels and contrasts together provide a deeper understanding of the sample condition. With ZEISS ZEN Connect, you can efficiently overlay multimodal image data together and quickly switch from the overall view to a high-resolution detailed display. All image data, including that from third-party providers, can be conveniently aligned, overlaid and displayed in context with ZEISS ZEN Connect.

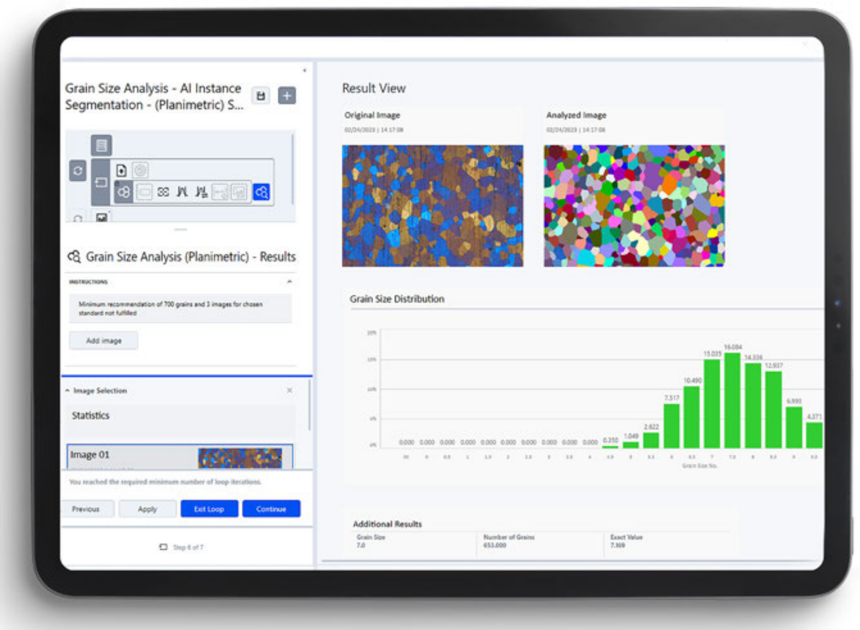
With ZEISS ZEN Connect, more information can be obtained more quickly, for greater certainty in microstructure evaluation.

ZEISS ZEN Connect

Correlation with light, digital and electron microscopes

Faster and more accurate testing using deep learning

ZEISS ZEN core provides automated image analysis for particle and phase analysis. Deep learning techniques significantly reduce the workload for these applications and always work reproducibly, according to the same trained patterns, regardless of the user and location.



The microscope image of an aluminium alloy is automatically segmented using deep learning. The algorithm reliably identifies individual grains. Touching and overlapping objects can be separated (instance segmentation).

ZEN core tool kits

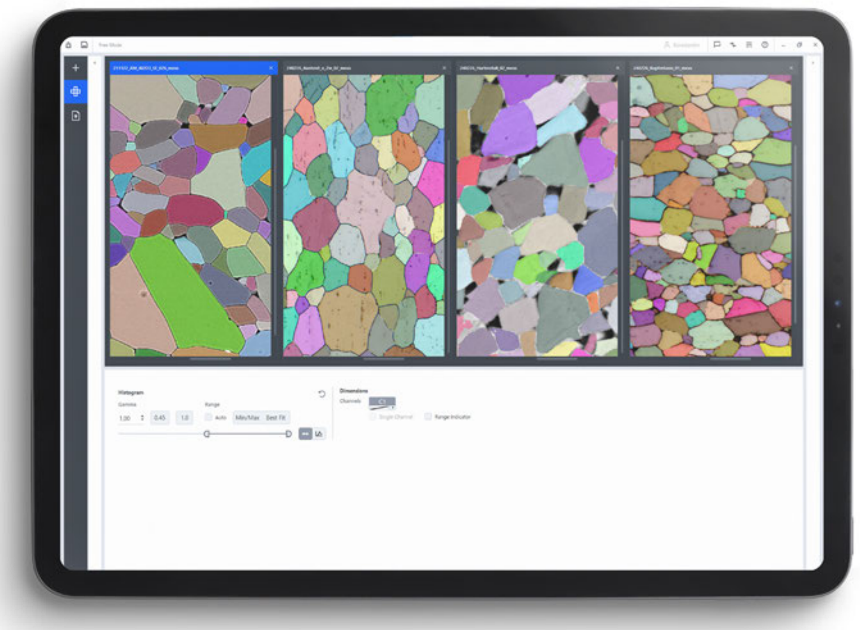
ZEISS ZEN core has a modular structure and can be individually expanded with the tools you need. Among other things, ZEISS offers these supplementary toolkits:

- **Material apps**
  Tools for grain size analyses, cast iron analyses, multiphase analyses, reference series comparisons and coating thickness measurements
- **AI toolkit**
  AI application kit for segmentation, object classification and image denoising, including training interfaces
- **2D toolkit image analysis**
  2D image analysis using automatic measurement programmes, including advanced processing
- **Developer toolkit**
  Programming of customised macros in the Python programming language, control of ZEISS ZEN core via an API interface
- **Data storage**
  Central SQL-based image database for intelligent data management with integrated user and access management
- **Connect Toolkit**
  ZEISS ZEN Connect allows you to align, overlay and correlate multimodal image data from different microscope types.

The latest deep learning models – locally or in the cloud

Depending on the respective micro-structure for the analysis task, ZEISS ZEN core enables segmentation using classic machine learning or the latest deep learning technologies. The deep learning models can be trained either locally in ZEISS ZEN core or in the secure ZEISS cloud environment.

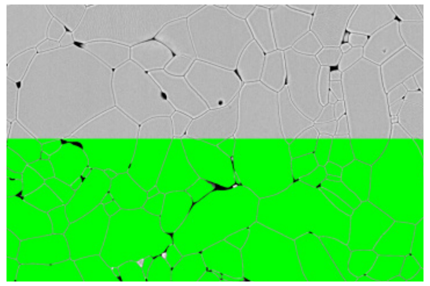
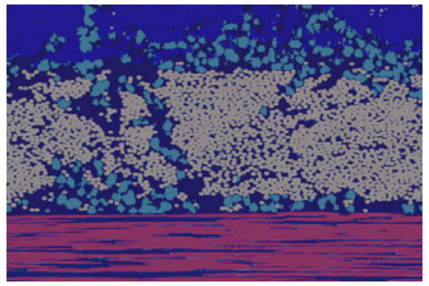
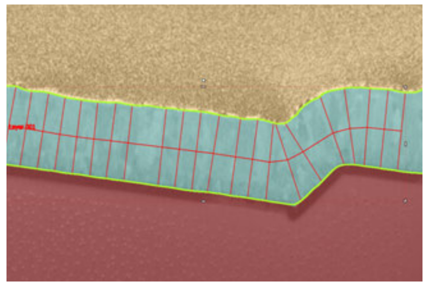
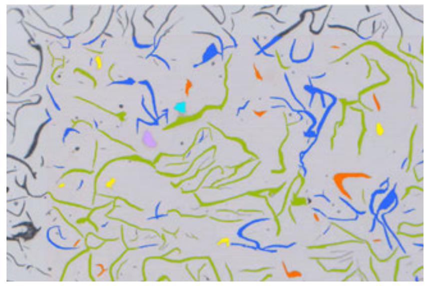
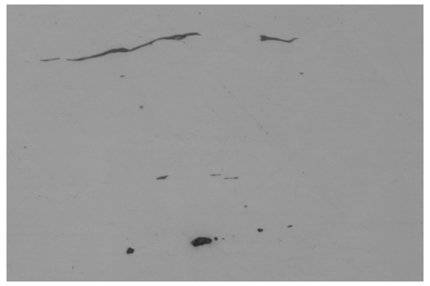
Both semantic pixel-based segmentation, in which each pixel is assigned to a class, and object-based instance segmentation, in which individual objects are recognised and assigned to classes, are possible.

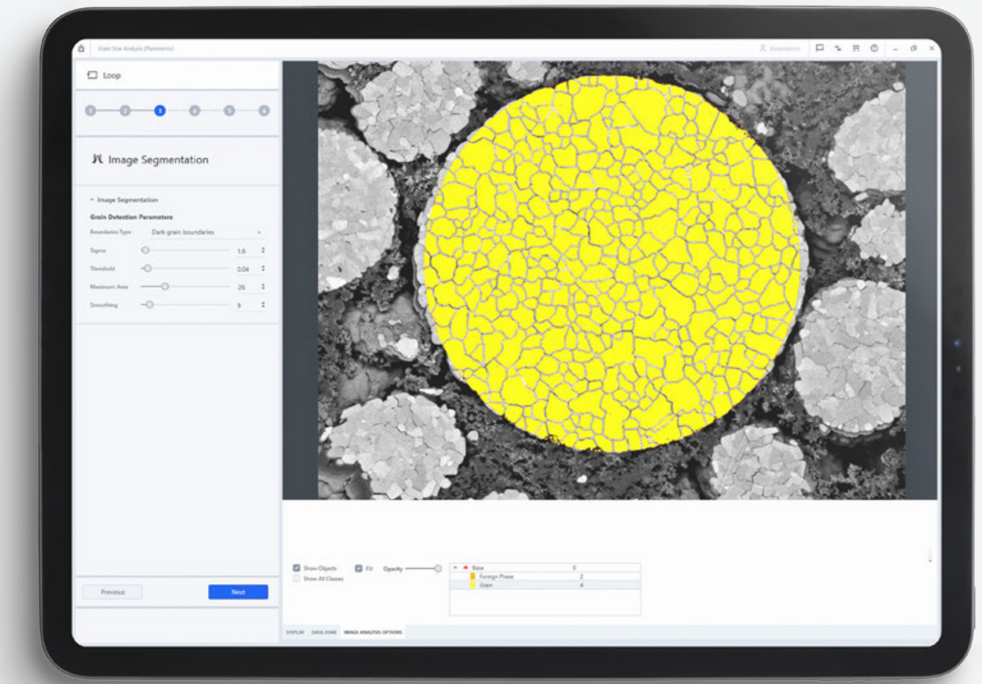


Automatic AI-supported determination of the grain boundaries of a ceramic, an austernite steel, a hard metal and a copper-based alloy sample. In this example, it was sufficient to train a deep learning model to reliably recognise the grain boundaries of all four materials.

Material characterisation with ZEISS ZEN core

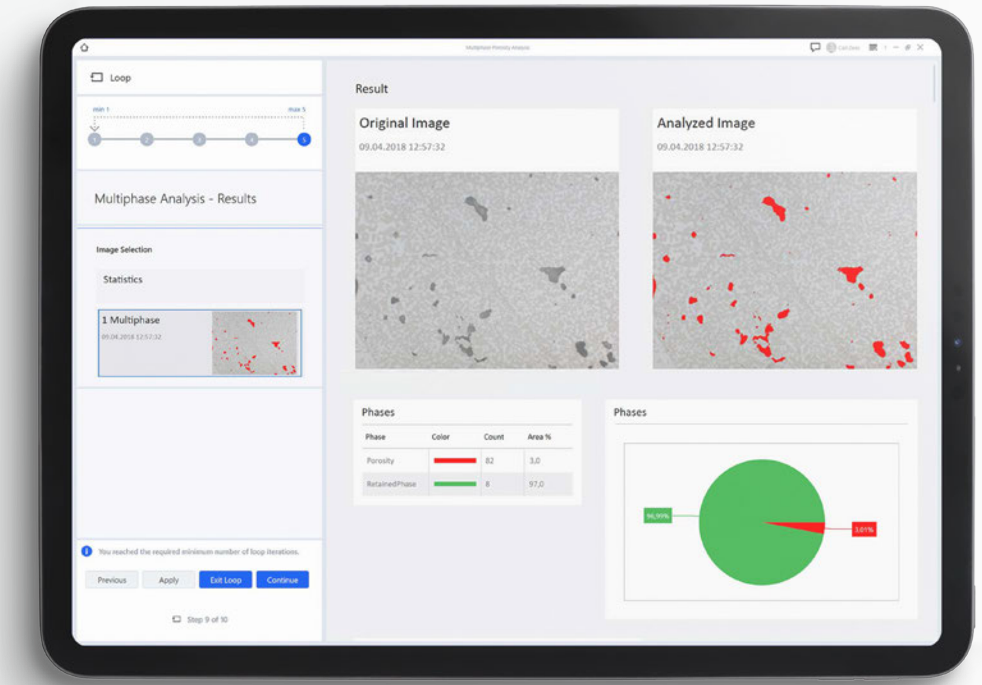
Simple standard-compliant evaluation

	Grain sizes	Multiphase	Layer thicknesses	Cast iron	Non-metallic inclusions
Application	Grain size distribution	Phase fraction determination	Automatic edge detection	Size, shape and distribution of graphite particles	Quantity and size of oxides, sulphides, nitrides and other inclusions
Image, evaluation	 *Technical ceramics, medical technology*	 *Carbon fibre reinforced plastic, aerospace*	 *Solar cell, renewable energies*	 *Grey cast iron, plant engineering*	 *Steel, plant engineering*
Remarks	Quantify the crystallographic structure of your materials according to international standards.	With this module, you can determine phases according to both their size and the percentage of the respective area. An important application is the investigation of porosity.	Measure the thickness of coatings or the depth of hardened surfaces in the cross-section of a sample. Evaluate complex coating systems either automatically or interactively.	Analyse the shape and size of graphite particles in cast iron fully automatically and determine the percentage of graphite particles by area.	This module allows you to analyse non-metallic inclusions in steel in order to assess steel purity. The standards-based automated workflow solution includes sample collection, inclusion classification and inclusion evaluation as well as results documentation and archiving.



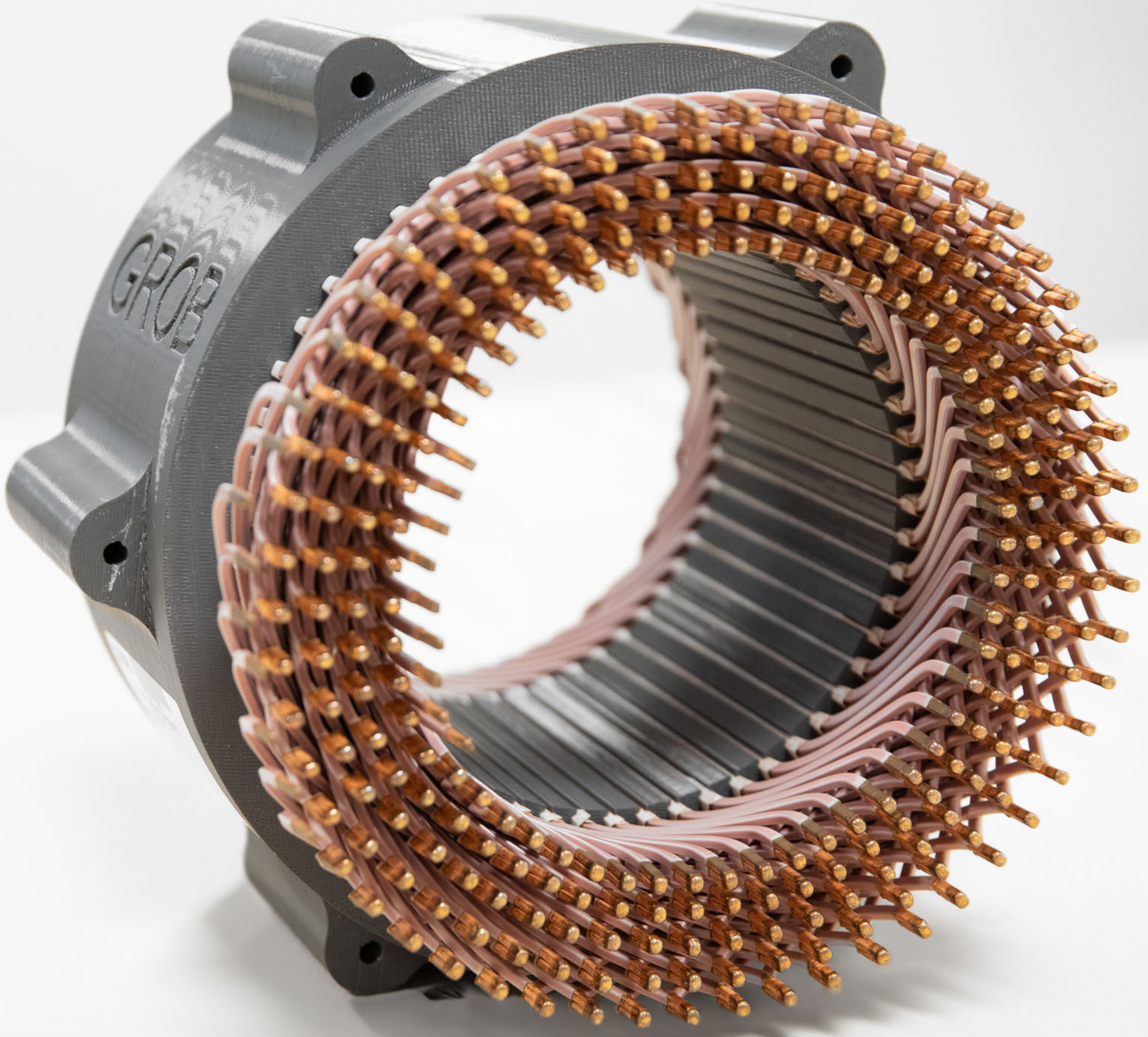
Example battery technology: grain size analysis of NCM cathode particles

The only marginally visible grain boundaries of NCM cathode particles can be revealed using a ZEISS electron microscope with an Inlense-EsB detector. An algorithm trained using deep learning then automatically and reliably segments the microscope image. The image analysed in this way can be used to determine the particle size distribution, for example.



Example: Multiphase analysis of a thermal spray coating

Thermal spray coatings improve the resistance of the substrate material to corrosion, heat or wear, among other things. The porosity of a metallographically prepared sample can be easily determined using multiphase analysis. The porosity determined allows conclusions to be drawn about the structure and hardness of the spray coating.



Hairpin stator manufactured with GROB machines

Application example GROB **Comprehensive quality inspection for hairpin stator production**

Today, stators for electric car traction motors are increasingly being produced using the so-called hairpin technology. The advantages over the standard winding process are the compactness of the hairpin stators and the fact that production can be better automated. GROB is a leading manufacturer of production systems for hairpin stators. To ensure the quality of these systems, the German family-owned company utilises various testing and measuring systems from ZEISS.

ZEISS Axio Imager Z2m

Microscopic tasks	Incoming inspection of copper wire, quality inspection of welding points
Benefits	Covers a wide range of tasks in quality assurance perfectly

Sample for incoming goods inspection

Checking the spot welds

Advantages and challenges of hairpin technology

Hairpin technology is gaining ground in the automotive industry because, compared to stators wound with round wire, hairpin stators require less space and have a higher fill factor, which also benefits the performance development of the electric motor. Above all, however, the production of hairpin stators can be more automated and therefore more economical. The biggest challenge of the process is ensuring process reliability. Bending points and spot welds are the most susceptible points of failure in the system and are therefore of particular importance in quality assurance.

Process steps in hairpin technology

In hairpin stators, the coil is made up of U-shaped wire elements. Their shape is reminiscent of a hairpin, hence the name of the technology. To produce the hairpins, flat copper wire is formed into a three-dimensional geometry using special bending equipment. Up to 16 different geometries can be built into one stator. In the next step, the plug-in coils pre-assembled into a hairpin basket are inserted into a laminated core and finally the neighbouring hairpin ends are welded and contacted with other electrical components, usually using a laser welding process.

Microscopy by ZEISS

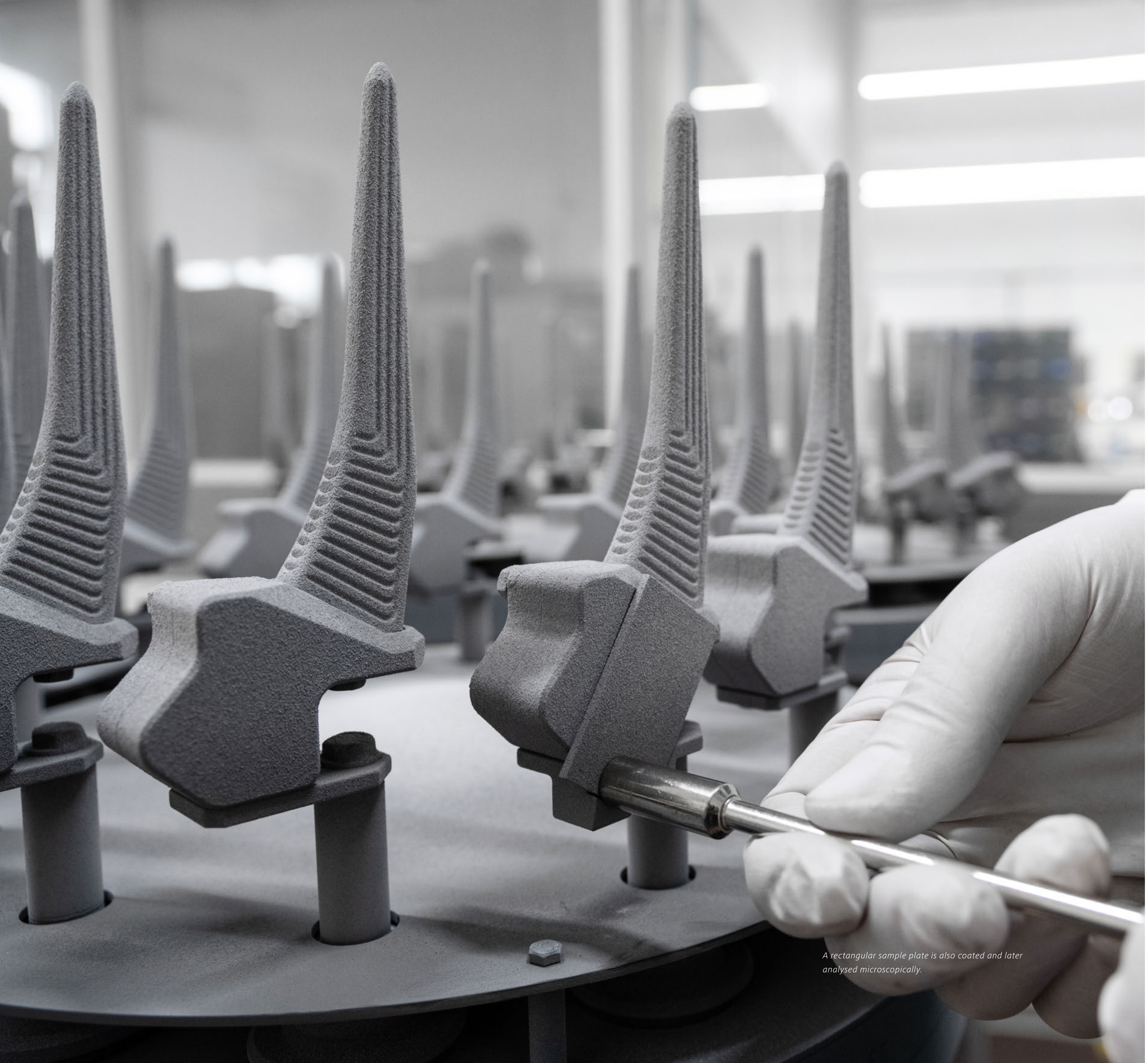
The machine manufacturer GROB uses a ZEISS Axio Imager Z2m microscope to ensure the quality of its production systems. On the one hand, the microscope is used for incoming inspection of the flat copper wire. The bending behaviour of the wire depends primarily on its material properties. A material defect can lead to dimensions not being adhered to, welding points being set incorrectly and the stator failing as a result. GROB uses the ZEISS Axio Imager Z2m to check the dimensional accuracy of the copper wire and measure the thickness of the insulating enamel layer.

After welding the hairpins and other components, the spot welds are randomly checked. GROB also uses the ZEISS Axio Imager Z2m for this purpose. The welding points are critical points of the construction. A single faulty contact impairs the function of the entire stator and can lead to failure.

Further measuring and inspection technology by ZEISS

ZEISS measuring and testing technology is used in many areas of quality assurance at GROB. In addition to the Axio Imager Z2m, the laboratory equipment includes a ZEISS PRISMO verity coordinate measuring machine and a ZEISS ATOS ScanBox. The bending result of the hairpins is checked optically with the ZEISS PRISMO verity CMM. GROB also checks the weld seams of the assembled stator with the ZEISS PRISMO verity, but this time with a tactile sensor. The final step in the quality inspection is a complete optical scan of the finished stator in the ZEISS ATOS ScanBox.

GROB benefits from the combination of different ZEISS inspection systems. The standardised and simple ZEISS operating philosophy reduces the amount of training required and speeds up work on the various systems. With the ZEISS cross-device reporting, the partial results can be easily combined into a coherent report. And in the event of quality problems, ZEISS provides an overarching contact partner who can provide neutral advice on the inspection technologies used and assume overall responsibility.



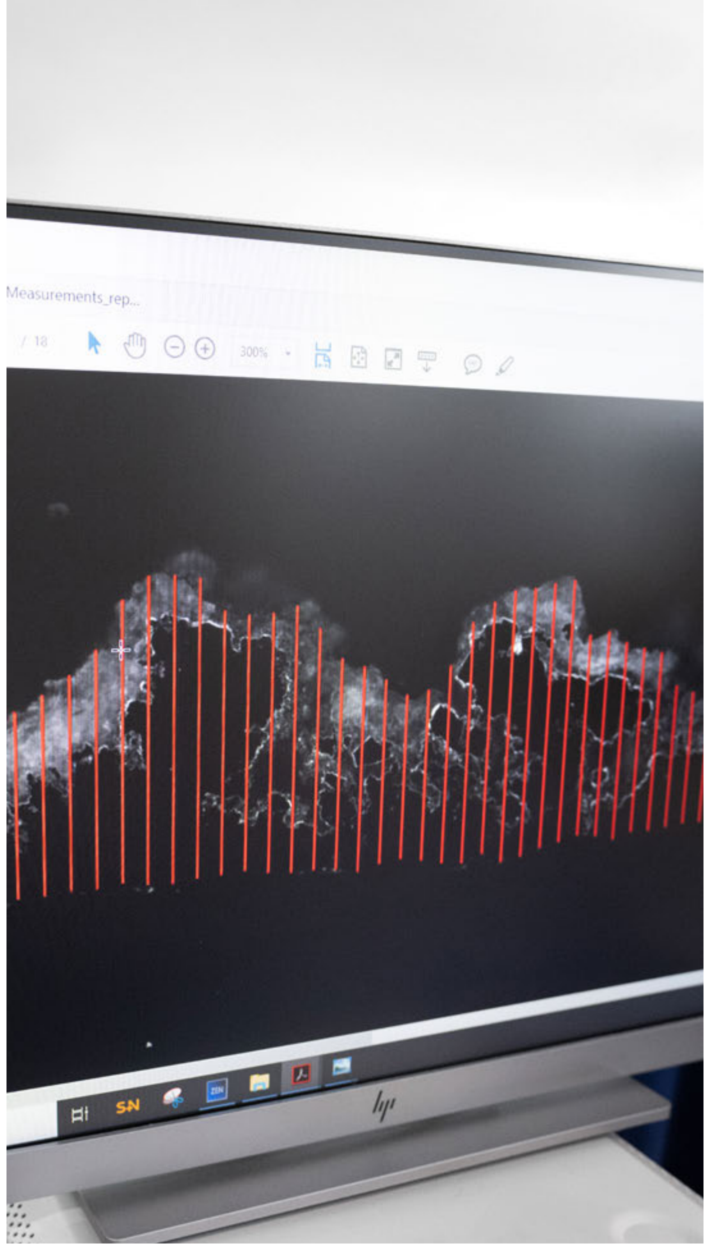
A rectangular sample plate is also coated and later analysed microscopically.

Application example Smith & Nephew **Fully automated, AI-supported testing of implant coatings**

The medical technology company Smith & Nephew manufactures artificial hip and knee joints at its site in Aarau, Switzerland. The implants enable patients to move again without pain. How well they grow into the bone depends on their coating. To ensure the quality of the coating, Smith & Nephew uses microscopy technology from ZEISS.

ZEISS Axio Imager Z2m

Microscopic tasks	Thickness, porosity, mean pore length, mesh interface and roughness of the titanium and hydroxyapatite coating
Benefits	Reproducibility, accuracy, 85 % time saving



ZEISS ZEN core sets 343 vertical lines fully automatically and calculates the coating thickness from them

The prostheses are coated in the vacuum chamber at a temperature of up to 20,000 degrees Celsius

The use of artificial hip and knee joints is a success story of modern medicine. The prognosis for the frequently performed operations is generally very good and promises significant pain relief and an improvement in movement functions. Patients not only regain their mobility with the implanted joints, but also a great deal of quality of life.

Prosthesis production with Swiss precision

With sales of over USD 5 billion, Smith & Nephew is one of the world's leading medical technology companies. Hip and knee implants are part of the Othopaedics segment of the globally active group. They are manufactured to the highest quality standards at the Swiss site in Aarau.

It's the coating that counts

An important step in the manufacturing process is the coating of the joint blanks with layers of titanium and hydroxyapatite - a bone substitute substance. The coating ensures good ingrowth of the implant and extends its durability. It is applied using vacuum plasma spraying (VPS) in state-of-the-art vacuum chambers at temperatures of up to 20,000 degrees Celsius. The quality of the coating determines how stable the bond between the bone and the implant will be. Smith & Nephew uses a ZEISS Axio Imager Z2m microscope to check compliance with the tolerance specifications.

Save time and increase quality

The ZEISS Axio Imager Z2m and the ZEISS ZEN core microscopy software are used to determine many quality parameters of the coating: the coating thickness, porosity, average pore length, mesh interface and roughness – and they do so particularly quickly, efficiently and reliably thanks to artificial intelligence. To determine the coating thickness, 50 vertical lines were previously drawn manually into the microscope image at the Aarau site, the length values determined were transferred to an Excel spreadsheet and then analysed. With the ZEISS ZEN core software, the layer thickness is now determined fully automatically and more accurately. Instead of 50 lines, the artificial intelligence sets 343 lines and delivers the result without operator intervention. Where the manual process took almost an hour, the result is now available in around 6 minutes with ZEISS ZEN core - a time saving of 90%. Because operator influence is eliminated, this result is also much more reproducible.

Porosity routinely according to standard

Manual determination of porosity is very time-consuming and has therefore only been used in individual cases in Aarau. With the ZEISS Axio Imager Z2m and ZEISS ZEN core, porosity is now one of the parameters that are routinely recorded. A deep learning algorithm places horizontal lines in the empty spaces and determines the porosity in accordance with the ASTM F1854 standard. If required, an evaluation in accordance with FDA 21 CFR Part 11 could also be implemented.

User-friendly deep learning

The deep learning algorithms are trained by ZEISS as required. With ZEISS arivis Cloud, a solution is also available for training models for image segmentation yourself – in a very user-friendly way and without programming knowledge.

What caused the crack in the pinion shaft? The SPC materials laboratory determined the cause of the defect using ZEISS microscopy solutions

Application example
SPC materials laboratory
Failure analyses on steel components

Defects in the casting or forming of steel can lead to corrosion, porosity, cracks or breakage. The consequential costs of such defects are often immense. The SPC materials laboratory in southern Germany investigates the causes of damaged steel products. The materials researchers at SPC use a digital microscope, an optical microscope and an electron microscope from ZEISS as well as the microscopy software ZEISS ZEN core.

ZEISS Smartzoom 5

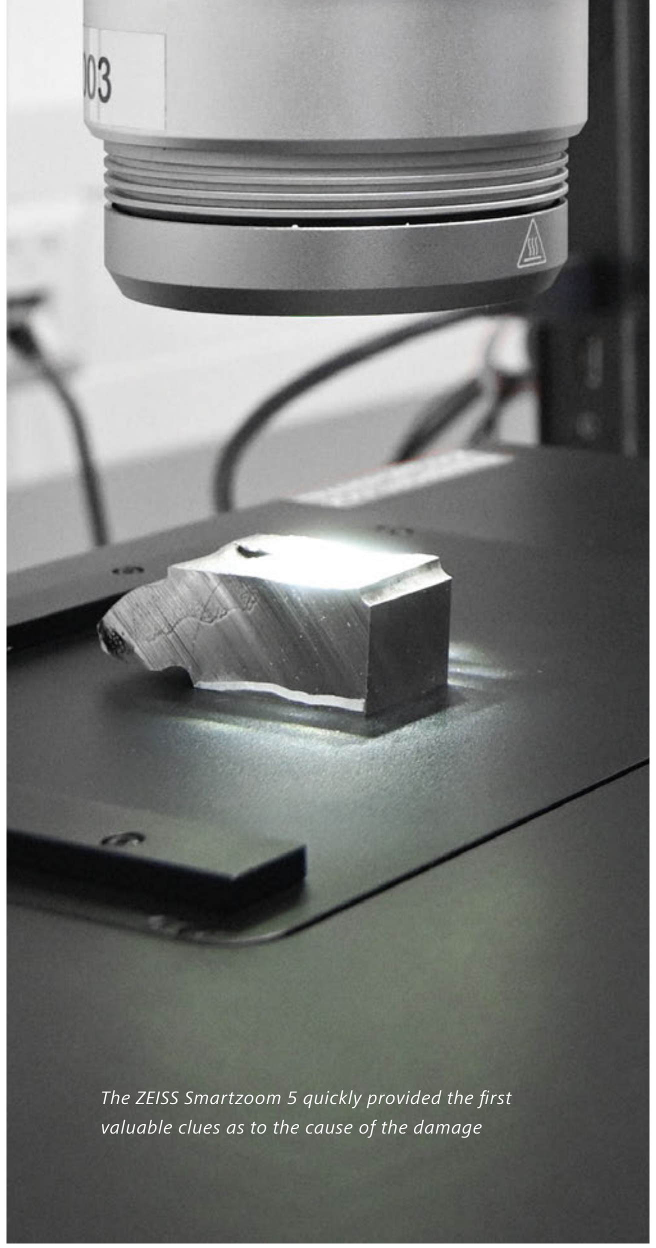
Microscopic tasks	Localisation and rough determination of the cause of damage
Benefits	Fast results thanks to automated functions and smart user guidance

ZEISS Axio Imager Z2m

Microscopic task	Detailed determination of the cause of failure
Benefits	High-resolution images with large image area

ZEISS EVO 15

Microscopic task	Chemical determination of contaminants
Benefits	Additional information on quality optimisation



The ZEISS Smartzoom 5 quickly provided the first valuable clues as to the cause of the damage

Steel is the material of the industrial revolution and has been a basic material of industrial progress ever since. Whether in the automotive industry, mechanical engineering, shipbuilding, aerospace, electrical industry or construction – steel is omnipresent and remains indispensable.

High demand and more complex requirements
Materials laboratories such as SPC are directly confronted with developments in the steel industry. The challenges facing steel producers and steel processors are more diverse than ever. In view of supply bottlenecks on the steel market, the need for quality measures to minimise rejects is growing. At the same time, there is increasing time pressure to quickly identify the causes of defects. This makes microscopy solutions that deliver fast and reliable results for each individual case all the more important.

Failure analysis of a pinion shaft
One example from SPC's day-to-day work is a cast steel pinion shaft. After casting, a complete batch of pinion shafts was torn open lengthways. The steel trader commissioned SPC to analyse the damage.

"At first glance, the fracture looked to us as if it had been caused by defect to the surface of the raw part during hardening," reports laboratory manager Thomas Schaupp, "therefore a crack from the outside inwards." But a closer look revealed a dark discolouration in the centre of the axle.

Localising the cause of damage
Using the ZEISS Smartzoom 5 digital microscope, SPC was quickly able to confirm this finding: The microscope image showed oxidation of the steel in this area – known as scaling. The cause of the damage could therefore be clearly localised in the core of the component.

Recognising the cause of defect
In order to analyse the microstructure in more detail, SPC took another sample, ground it and etched it with acid. Under the high-resolution ZEISS Axio Imager Z2m wide-field microscope, 'segregation' had taken place near the central axis, i.e. contamination; in addition, SPC saw non-metallic inclusions of foreign material. This caused the steel to become brittle.

Determining impurities
Using the ZEISS EVO 15 scanning electron microscope, the experts at SPC were also able to determine the chemical composition of the impurities. The microscopy method of energy dispersive spectroscopy (EDX) revealed: In the steel of the pinion shaft, there were non-metallic inclusions with high concentrations of manganese and sulfur near the central axle, as well as segregations of sulfur and phosphorus.

Providing reliable results
SPC was also able to determine for the steel producer that the impurities were within the standard required by the customer. However, as a hole was drilled in the centre of the axle, which placed particular stress on the material, it broke. According to laboratory manager Schaupp, the pinion manufacturer should have set tighter tolerances for the steel supplied due to this hole.

Fast results with ZEISS microscopy solutions
Two points are essential for SPC's customers: the reliability of the result and the fastest possible analysis. In the case of the pinion shaft, SPC was able to deliver a detailed and reproducible result within a few days. The microscopy solutions from ZEISS played a decisive role in this. The use of various microscopes – from digital to electron microscopes – enabled SPC to proceed effectively step by step. In each step, further information could be obtained to precisely determine the cause of the defect, building on the previous results.

The ZEISS Smartzoom 5 revealed weakening oxidation in the core of the component

Using the ZEISS EVO 15 scanning electron microscope, SPC was also able to determine the chemical composition of the impurities

Under the wide-field microscope ZEISS Axio Imager Z2m impurities in the joints of the crystal lattice became visible

Software for greater effectiveness

Using the ZEISS ZEN core software, SPC was able to easily correlate the results of light and electron microscopy and analyse them together. ZEISS hardware and software are optimally harmonised. ZEISS ZEN core supports users with simple user guidance and numerous automated functions during image acquisition, processing and evaluation. This reduces the influence of the individual user and improves reproducibility.

Cloud-based database

SPC uses a cloud-based database from ZEISS to provide its customers with complete, transparent and convenient material analysis results. “Sending PDFs by email is no longer in keeping with the times,” says Laboratory Manager Thomas Schaupp, “in times of digitalisation, we and our customers expect solutions like this.”

Investigating the crystal structures of metals

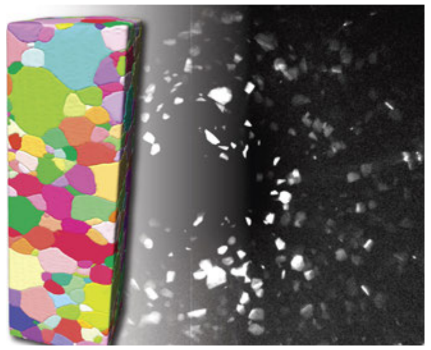
X-ray microscope ZEISS CrystalCT

ZEISS CrystalCT is the first commercially available computer tomography system that visualises crystallographic grain structures. It takes the examination of polycrystalline materials such as metals, alloys and ceramics to a new level. This was made possible by newly developed diffraction contrast methods. In addition, ZEISS CrystalCT eliminates sample size limitations and enables a wide variety of sample types to be analysed quickly and non-destructively.

ZEISS CrystalCT

Inspection tasks	Analysing crystal and micro-structures in metals and alloys
Benefits	Fast examination, large sample volume, unique technology to visualise crystal structure

Crystal structure of an aluminium-copper alloy, used for example in aircraft construction due to its low specific weight



Crystal structure of titanium, used for example as a base material for implants

Crystal structure of an ultra thin oriented electrical steel sample, used for example in electric motors, transformers or generators

Diffraction contrast make the crystal structure visible

ZEISS CrystalCT utilises two different imaging techniques: the established tomography technique using absorption contrasts and a new technique that uses diffraction contrasts for imaging. This Diffraction Contrast Tomography (DCT) was developed by ZEISS in partnership with Xnovo Technology. This makes it possible for the first time in a commercially available CT device to image the grain structure of metals, alloys and ceramics in three dimensions. Diffraction contrast tomography also enables in-situ 4D studies to analyse the effects of different conditions over time.

Representative data for virtual material testing

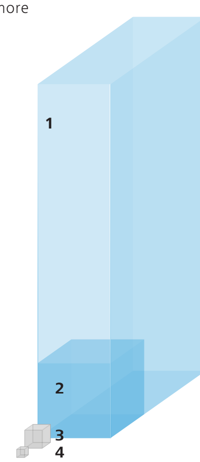
Virtual material testing speeds up the development of new materials enormously. In order to create the computer models as realistically as possible, a large amount of real test data is required. Conventional destructive methods for grain characterisation are very time-consuming and only provide a small amount of data. ZEISS CrystalCT, on the other hand, captures much larger sample volumes and delivers a data-illustrated digital image of the three-dimensional crystal structure – in a fraction of the time. The new type of diffraction contrast tomography eliminates volume limitations and makes it possible to analyse a large number of different sample types. This makes ZEISS CrystalCT the ideal data provider for virtual material testing.

1
Non-destructive CrystalCT
Volume: >>(1000)³ µm³ and more
Isotropic voxels: up to 2 µm
Voxel aspect ratio = 1

2
Non-destructive DCT
Volume: >>(1000)³ µm³
Isotropic voxels: up to 2 µm
Voxel aspect ratio = 1

3
PFIB + EBSD
Volume: >>(250)³ µm³
Layer thickness: 0.2 - 5 µm
Voxel aspect ratio ≥ 50

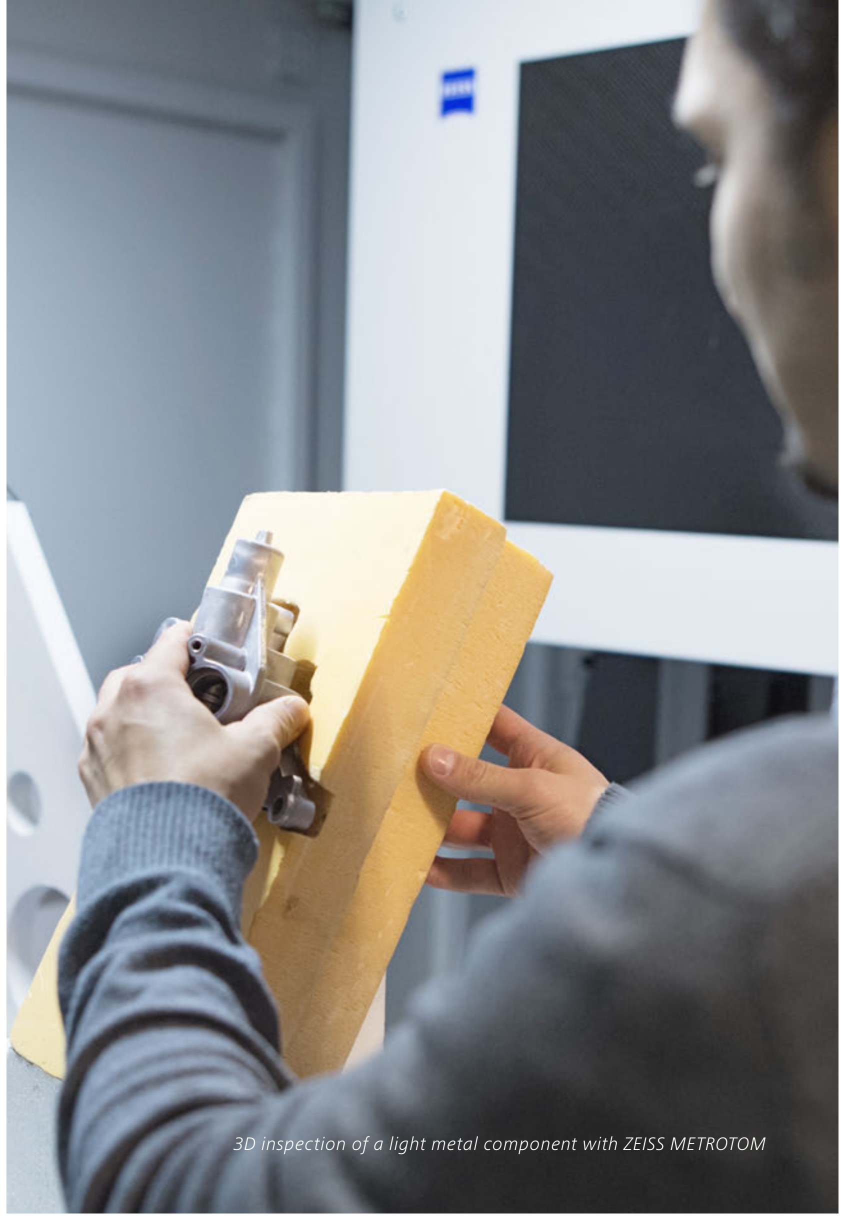
4
Ga-FIB + EBSD
Volume: >>(100)³ µm³
Layer thickness: 10 nm
Voxel aspect ratio ≥ 1



The innovative diffraction-contrast tomography of ZEISS CrystalCT significantly increases the analysable sample volume

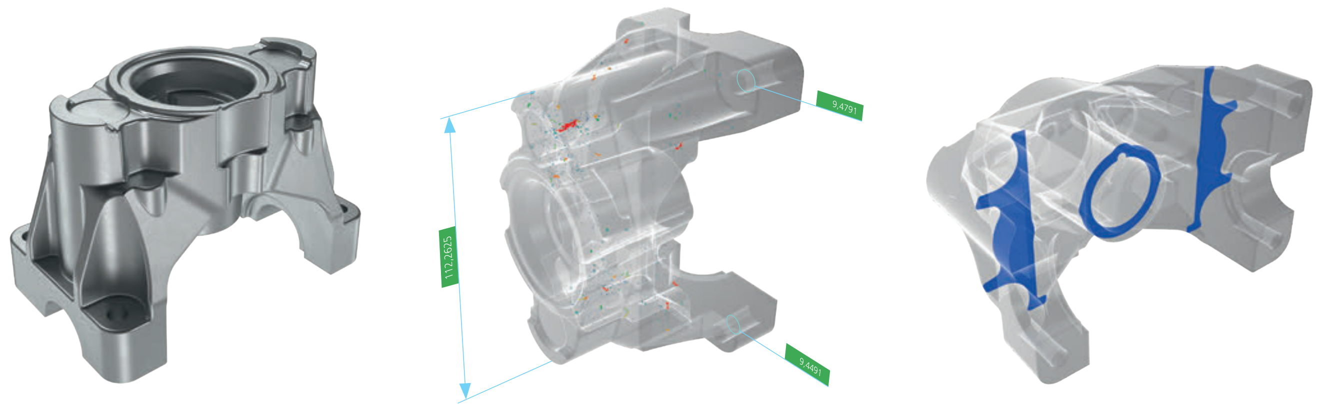
Non-destructive X-ray inspection of entire components
Computer tomograph ZEISS METROTOM

With a computer tomograph from ZEISS, you can perform even complex measuring and inspection tasks efficiently and non-destructively with just one X-ray scan. The standardized acceptance, the precision mechanics used and the sophisticated calibration procedure guarantee the traceability of the system. Linear guides and rotary table fulfil the highest demands on accuracy.


3D inspection of a light metal component with ZEISS METROTOM

ZEISS METROTOM

Inspection task	Non-destructive testing of hidden structures
Benefits	Reliably replaces many time-consuming inspection procedures with a 3D scan and provides a comprehensive digital image


ZEISS METROTOM provides information on geometry, cavities and internal structures

Measure and analyse entire components
ZEISS METROTOM is an industrial computer tomograph for measuring and testing complete components made of plastic or light metal. Hidden structures, which can only be inspected with conventional measurement technology after the complex layer-by-layer destruction of the component, can be visualised and analysed by ZEISS METROTOM in the simplest possible way.

Full CT data analysis in 3D
The easy-to-use ZEISS INSPECT X-Ray analysis software, which is also suitable for beginners, enables complete CT data analysis in 3D. Geometries, cavities or internal structures and assembly situations can be precisely analysed. Even the smallest defects can be visualised using individual sectional images and can be automatically evaluated using a wide range of criteria. You can also load volume data from several components into a project, perform a trend analysis and compare the analysis with CAD data. This means that the quality of your component can be precisely determined and documented - all in just one piece of software.

Application example: Testing of cast raw parts for process optimisation
The Austrian printing and injection moulding company TCG UNITECH uses a ZEISS METROTOM 1500 in the immediate vicinity of its 20 die casting machines in production. This enables quality fluctuations to be detected quickly and reliably. If porosity is detected, for example, the ZEISS METROTOM indicates whether it is due to air inclusions or shrinkage. With this important information, employees can immediately adjust the casting process parameters to avoid rejects. Many time-consuming inspections that were previously necessary are no longer necessary with ZEISS METROTOM. The computer tomograph eliminates the need for destructive testing procedures. ZEISS METROTOM delivers comprehensive results quickly with just one 3D scan. TCG UNITECH also uses the 3D X-ray machine to design cast blanks via reverse engineering and when introducing new series components. ZEISS METROTOM delivers fast results for validation with the customer and thus accelerates the release for series production.

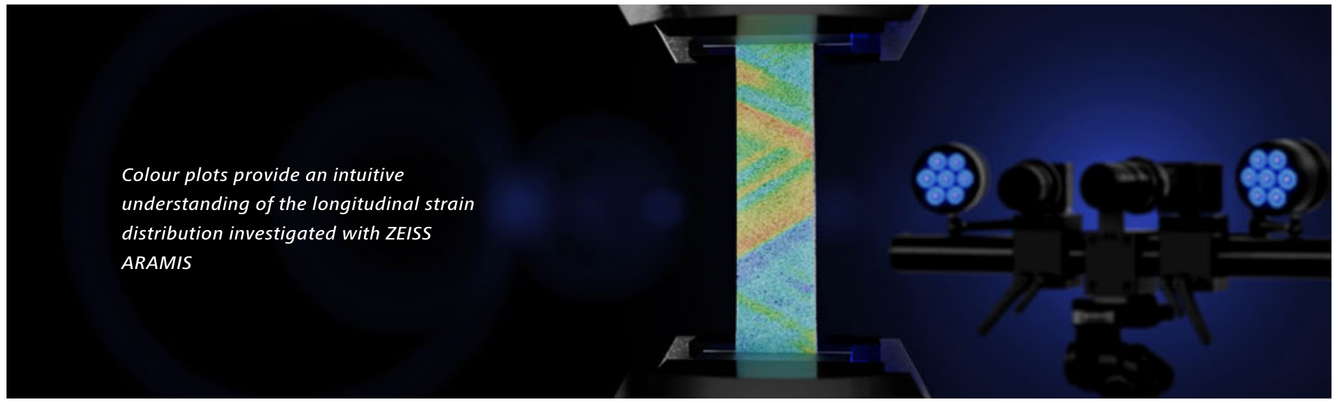
Optical analysis of tensile tests
3D-sensor ZEISS ARAMIS

ZEISS ARAMIS provides a deeper and more precise understanding of material properties during tensile tests. Using high-resolution or high-speed cameras, the optical 3D sensor provides the exact coordinates of the sample surface over time without contact and thus the derived measured variables of strain, displacement, velocity and acceleration. The visualisation of the strain distribution gives you a quick overview of the force effects on the material surface. You can also use the image data from ZEISS ARAMIS to determine material characteristics and validate numerical simulations.


The analysis of a tensile test with ZEISS ARAMIS provides a precise understanding of the deformation behaviour of the material under test

Optical 3D sensor ZEISS ARAMIS

Inspection task	Investigate deformation behaviour in detail
Benefits	Complete analysis of strain behaviour, high data density, low sample preparation effort, easy-to-understand colour plots.


Colour plots provide an intuitive understanding of the longitudinal strain distribution investigated with ZEISS ARAMIS

Application example: Validation of numerical models for bolt connections
With regard to the use of bolts in the aerospace industry, bolt connections on CFRP components were analysed in a tensile test. The aim of the research was to use the data from ZEISS ARAMIS to check numerical models of material behaviour. Thanks to the graphically visualised high-resolution image data, strain peaks could be precisely localised and the behaviour of the sample intuitively illustrated. Due to the low preparation effort, a large number of samples could also be analysed efficiently.

Contactless strain distribution measurement with ZEISS ARAMIS
The measurement of inhomogeneous strain distributions is not possible with conventional tactile strain measurement technology. The ZEISS ARAMIS optical 3D sensor delivers thousands of measured strain values and visualises the strain distribution on the surface of the material sample in easy-to-understand colour diagrams. Even the strain behaviour shortly before the material sample fails is reliably recorded by ZEISS ARAMIS.

The complete picture - quick and easy
Measure thousands of strain data points without contact. Save time and money on sample preparation. Material samples only need to be prepared with a black and white random colour pattern. There is no need to spend time attaching strain gauges that only provide one data point. Thanks to the non-contact measuring principle with camera technology, ZEISS ARAMIS offers enormous flexibility in terms of sample material, sample shape and temporal measurement resolution.

Analyse strain and temperature distribution synchronously
By combining ZEISS ARAMIS with a thermographic infrared camera, the strain and temperature distribution in the sample can be analysed separately but synchronously. In a tensile test, for example, this makes it possible to determine when the deformation is elastic (causes cooling) and when it is plastic (causes heating). The combined data can also be used to validate numerical simulations.


Recording the strain behaviour of a open hole tension specimen with ZEISS ARAMIS

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