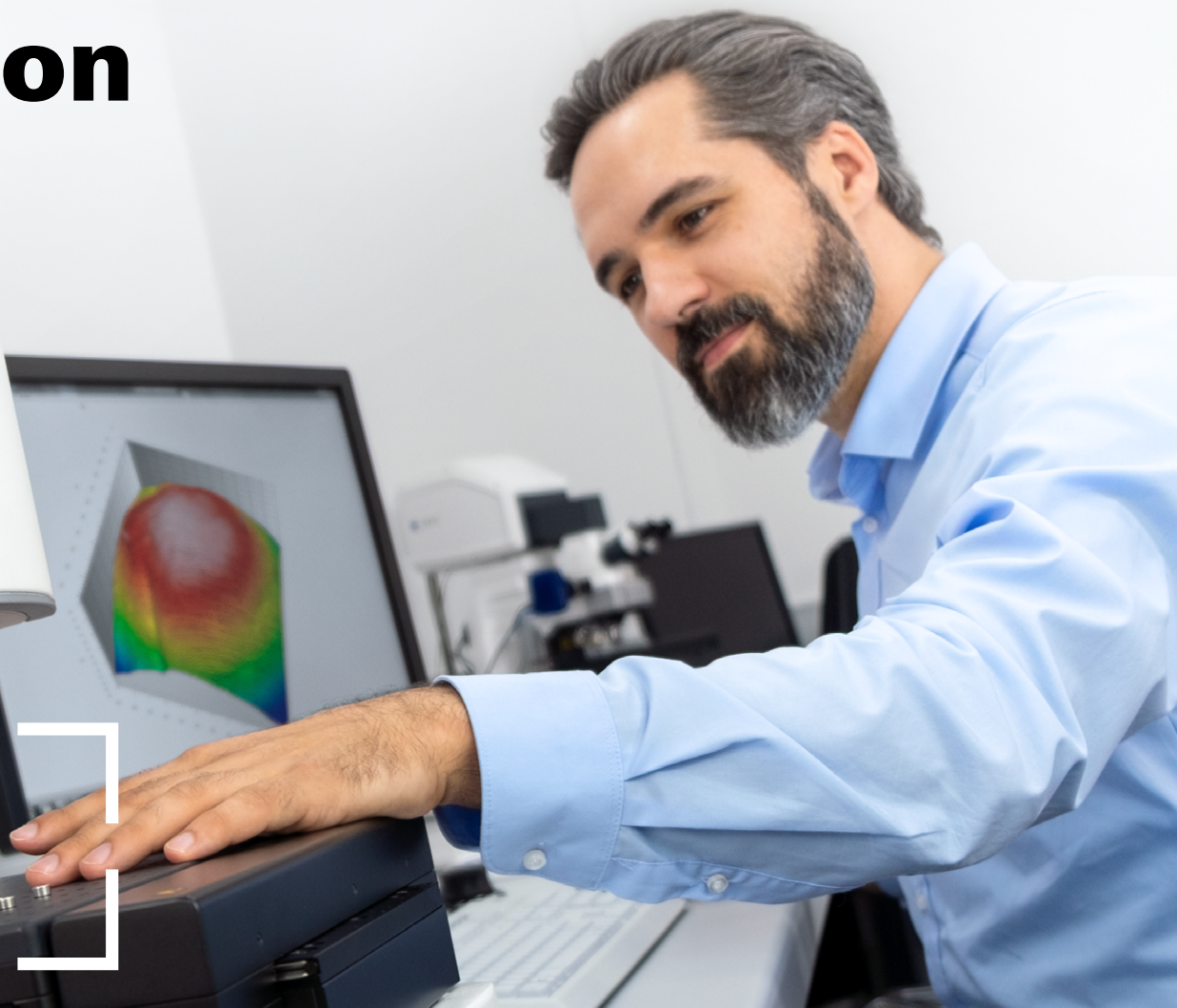# Surface Perfection

Smartproof5

ZEISS Smartproof 5

Your Widefield Confocal Microscope for Routine and
Automated Surface Analysis in Quality Control and Research

ZEISS

Seeing beyond

zeiss.com/smartproof

Dedicated Design. Guided Workflow. Trusted Output.

ZEISS Smartproof 5 is an integrated widefield confocal microscope, combining fast confocal technology for roughness and topography measurements with light microscopy imaging and documentation functions.

Dedicated optics enable unrivaled speed and accuracy for 3D data acquisition, providing raw data without pre-processing for results you can trust. Integration of motorization, LED based illumination and optics enable automated operation that yield reliable, certified and user-independet results in any environment.

Based on the software suite ZEISS ZEN core, you can choose between free-form and guided workflows, store and share results, and use advanced image analysis and reporting functions. In addition, the capability to correlate light, confocal and electron microscopy enables you to gain maximum information from your part or insights into your sample.
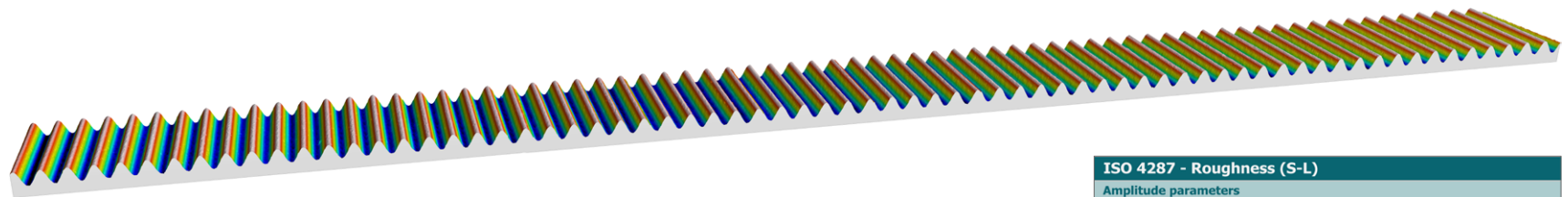
Raw data of a 3.0 µm roughness standard measured using a 20x objective
Measurement length 6 mm created by stiching of individual images, no data processing/filtering applied.

ISO 4287 - Roughness (S-L)			
Amplitude parameters			
Rp	5.01	µm	*Maximum peak height of the roughness profile*
Rv	4.80	µm	*Maximum valley depth of the roughness profile*
Rz	9.80	µm	*Maximum height of roughness profile*
Rc	9.45	µm	*Mean height of the roughness profile elements*
Rt	10.1	µm	*Total height of roughness profile*
Ra	2.99	µm	*Arithmetic mean deviation of the roughness profile*
Rq	3.33	µm	*Root-mean-square (RMS) deviation of the roughness profile*

Simpler. More Intelligent. More Integrated.
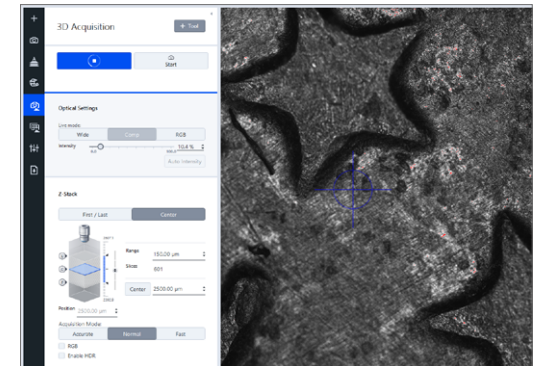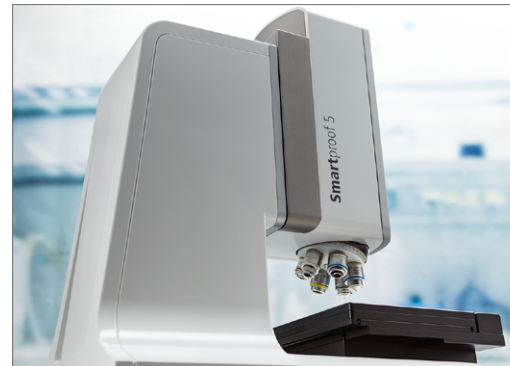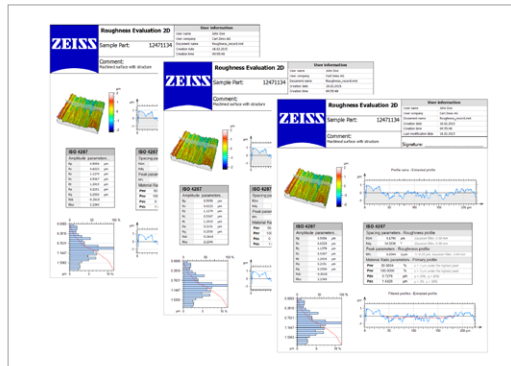
Trusted Results @Speed

As a widefield confocal microscope, Smartproof 5 is based on the Aperture Correlation technology which combines the benefits of classical confocal systems: high resolution, with the benefits of spinning disc systems: high acquisition speeds. Dedicated optics designed for the 405 nm LED illumination reveal accurate surface details even at low magnifications. Additional RGB LED illumination enables color imaging and documentation.

Integrated & Robust Design

Smartproof 5 gives you the benefit of a fully integrated system design: motorization, optics, electronics and camera are all enclosed in the microscope to provide a self-contained clutter free system. The entire system is built in a compact manner and its sturdy construction withstands vibration so effectively that there is no need for extra anti-vibration equipment. The robust design offers you the choice of installing and running Smartproof 5 in many different working environments – not only in labs but also on the shop floor.

Workflow-based and Connected

Run by ZEN core, Smartproof 5 combines all known benefits of a fully integrated solution into your connected laboratory environment. Free-form or guided workflows for data acquisition and analysis enable the system to be operated by untrained users or to simply speed up your investigation. As ZEN core is the ZEISS imaging software for light, confocal, and electron microscopy, training efforts will be minimal, and data correlation across different modalities will provide maximum information. By using the powerful ConfoMap software for data analysis, you can measure geometrical parameters and carry out roughness analyses in 2D (line profile) and 2.5D (area), based on ISO standards.

Faster Confocal Technology For Trusted Results @Speed

The main feature of a confocal microscope is its aperture (usually called a pinhole) which is arranged in such a way that out-of-focus information will be blocked and only in-focus information can be detected. In-focus information appears bright while out-of-focus information is dark. The sample is scanned vertically in pre-defined steps obtaining a stack of images, during which every point on the surface passes through the focus level. The height of the surface at each pixel location is determined from the intensity variation of each pixel within the z stack, which allows the reconstruction of the topography of the scanned surface represented by a color-coded height map.

In traditional spinning discs systems using conventional multi-pinhole discs or spinning disc, a high acquisition speed can be achieved, however at the cost of crosstalk – out-of-focus information from adjacent or neighboring pinholes – that decrease the z-resolution dramatically. While point scanners, like classical laser scanning microscopes, have no crosstalk and thus the highest resolution, they lack speed in comparison.

Smartproof 5 is based on the Aperture Correlation technology which combines the benefits of a point (one pinhole) scanner – its resolution, with the benefits of spinning disc systems – there high acquisition speeds. Using a spinning disc that consist of various segments with different structures, Smartproof 5 can acquire both the spinning disc data and a widefield image (crosstalk information). By combining both, the system obtains point-scanner-like resolution at high speed.
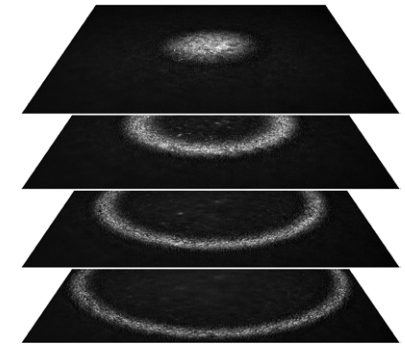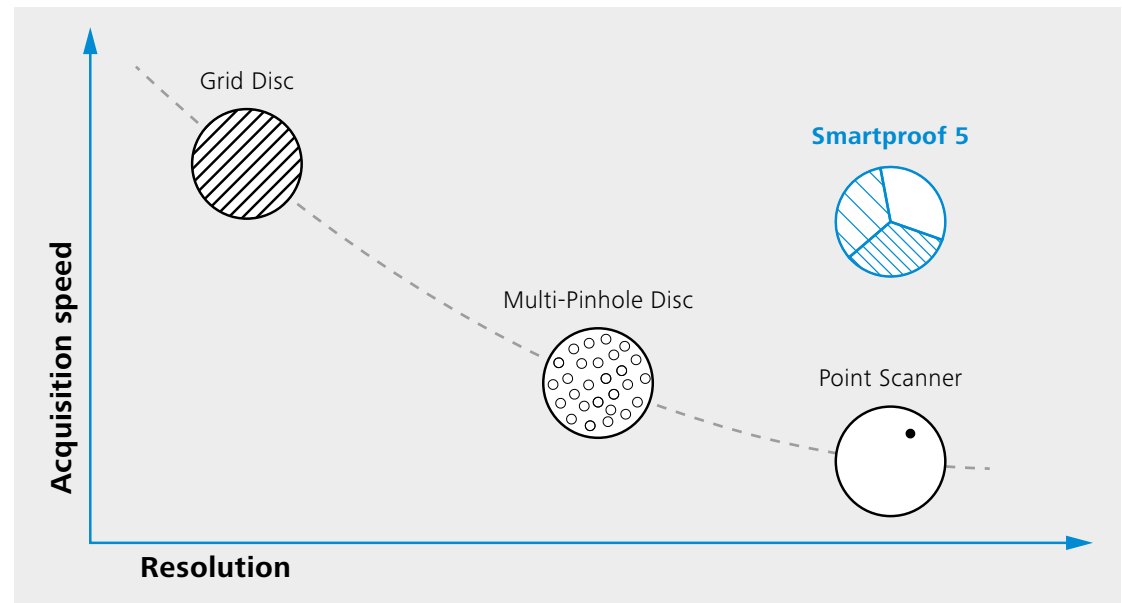

Image stack acquired along the Z axis; in-focus information appears bright while out-of-focus information is dark


Acquisition speed versus resolution: Smartproof 5 combines high resolution – like a point scanner – with high acquisition speeds – like a spinning disc system.

High-Resolution Imaging Thanks to Dedicated ZEISS Optics

Dedicated optics with high numerical apertures and optimized for the violet (405 nm) LED light source – the wavelength used for widefield confocal imaging – provide the basis for high-resolution imaging and data quality, even at low magnifications (see also technical specification of the objectives at the end). They also perform excellent with the integrated RGB LEDs, in order to provide true color images. Overlaying texture and 3D topography information result in a realistic surface reconstruction.
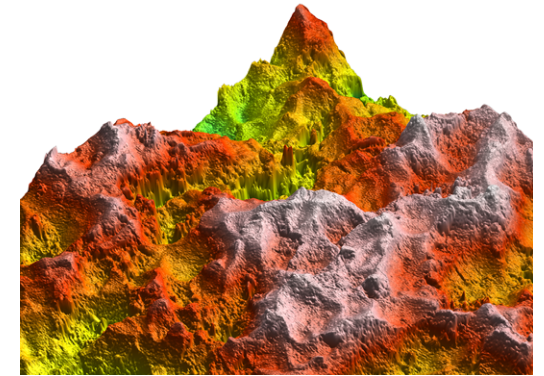
Surface of an additively manufactured metal part; 3D view with color-coded height map
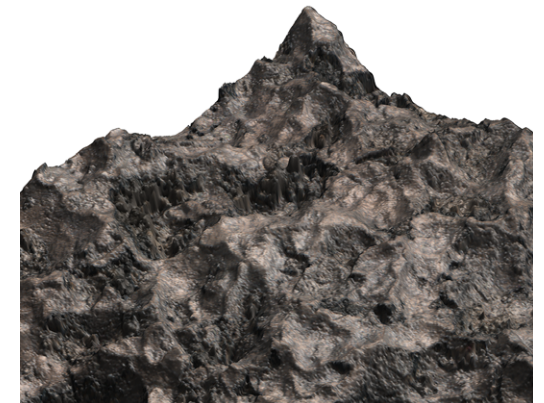
Surface of an additively manufactured metal part; 3D view with true color texture overlay

5

Integrated & Robust Design for Highest Performance

Based on its robust design, integrated motorization and LED-based illumination, Smartproof 5 offers you the choice of installing and running the system in many different environments: on your lab bench, in your office or on the shop floor—even without additional anti-vibration equipment.

The scanning stage has a surface area of 300 mm × 240 mm with threaded holes, enabling you to mount holders or fixtures for a variety of different parts to be measured or investigated. The travel range of 150 mm × 150 mm allows you to analyze different regions on a large part or multiple samples in one pass, in an automated fashion.

Smartproof 5 monitors the status of its own mechanical components to ensure optimal performance and preventive detection of potential service issues.
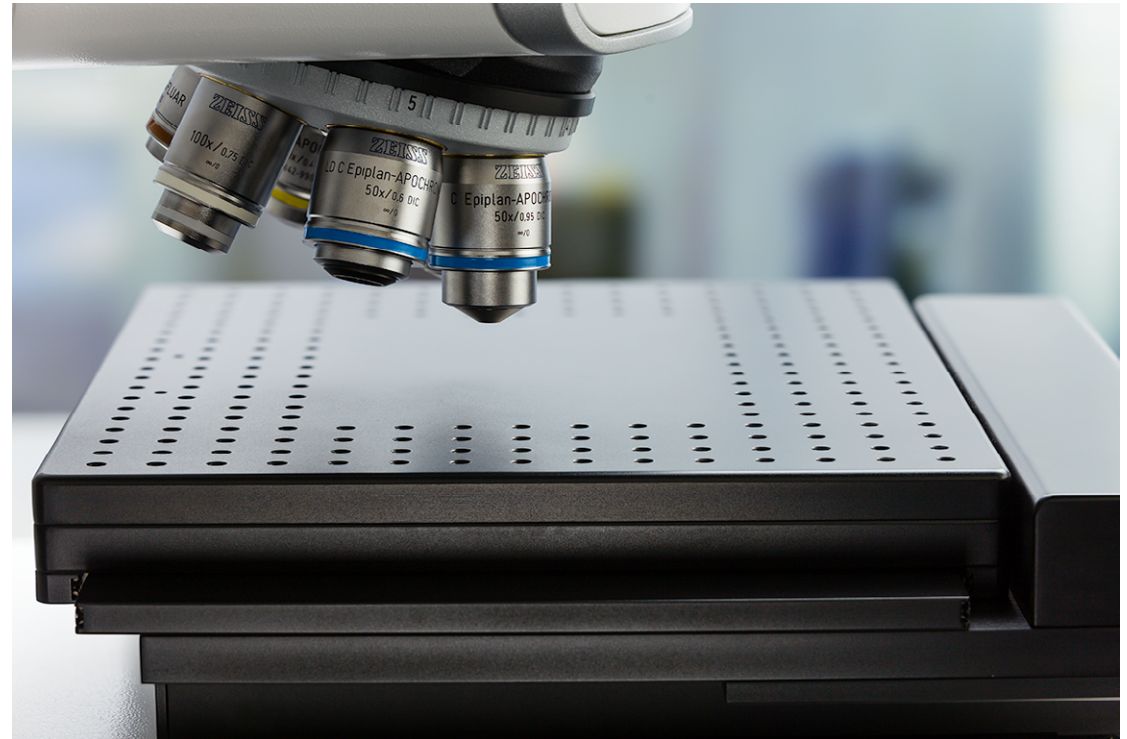
Advanced Data Correlation for Maximum Insights

Correlation between light, confocal, and electron microscopy tools becomes easy, since any region of interest that was identified with Smartproof 5 can be marked using the Shuttle & Find functionality within ZEN core, and at a simple click of a button, the same region can be retrieved in e.g. an electron microscope for further analysis. This eliminates the seemingly endless attempts to relocate the same region of interest at high magnification and at total different contrasts and thus speeds up your analysis.
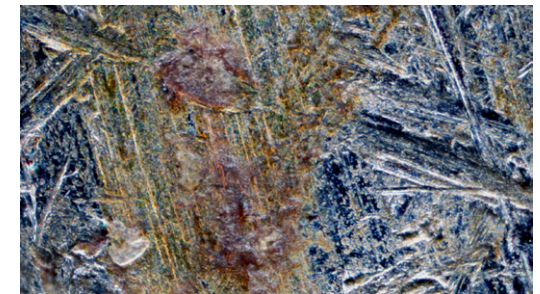
Data correlation example showing corrosion on a metal sealing surface, acqired with confocal, light, and electron microscopes (images show 500 μm x 300 μm field of view):
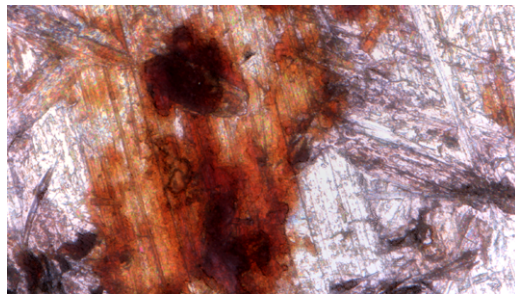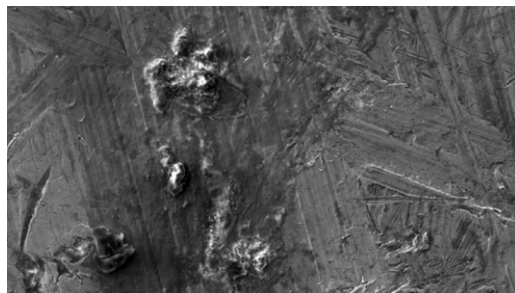
*True color image aquired with Smartproof 5 using co-axial illumination*
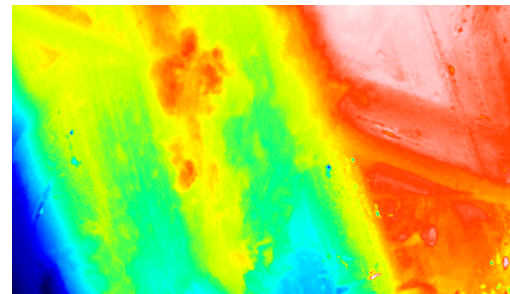
Height map created based on surface information aquired with Smartproof 5

Light microscopy image aquired with ZEISS Smartzoom 5 digital microscope using ringlight illumination

High-resolution imaging aquired with ZEISS EVO scanning electron microscope (Secondary Electron, SE) for morphology contrast
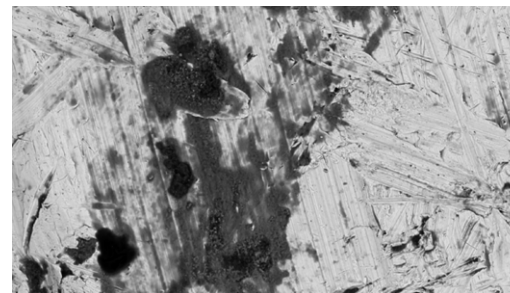
High-resolution imaging aquired with ZEISS EVO scanning electron microscope (Back-scattered Electron, BSE) for compositional contrast
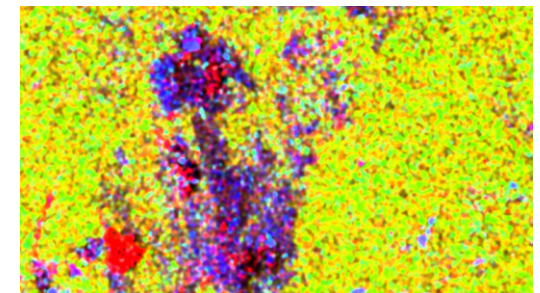
Elemental information aquired with ZEISS EVO scanning electron microscope (Energy-dispersive X-ray spectroscopy, EDX)

# Workflow-based Software for Automated Data Acquisition and Imaging

Smartproof 5 is run by ZEN core, the ZEISS software suite for microscopy imaging, analysis, and workflow connectivity, thus provides all known benefits of a fully integrated solution into your connected laboratory environment: user management, images and results database, as well as integrated reporting.

The operating concept also provides the choice between two working modes: free and job mode, whereas the latter is a guided workflow, which can be freely designed to your routine measurement and imaging tasks. The workflow consists of all necessary steps to have a reproducible image acquisition, whereas – once set-up – the operators have only to press "next" in order to execute the necessary pre-defines steps, one after the other. This speeds up routine task and enables the use of the system for untrained users, while not compromising data integrity or system safety.

ZEN core also provides all functions for 2D microscopy image acquisition, measurement and documentation. In addition, all advanced image analysis and measurement software packages are available, including Machine Learning for image segmentation (ZEN Intellesis) and simple to use yet sophisticated 2D metrology (NEO pixel).

Analysis Automation

In order to guide and automate your analysis or research, stitched overview images can be acquired to have a full representation of the sample or part under investigation. Then the regions for surface analysis are defined within the context of this overview image. The measurement can then be set-up to run automatically in user-defined regions. This is essential to create statistically relevant data, acquire information from distinctly different regions of your part or to simply speed up your process.
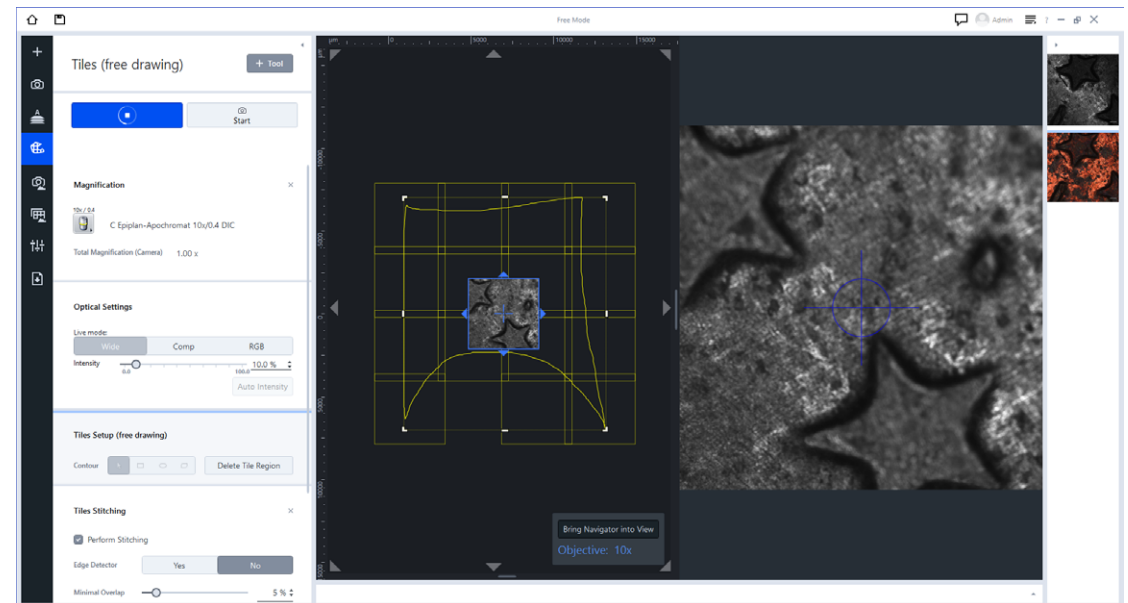

ZEN core user interface: free-form mode

Connected Workflow Solutions

- ZEN core is the ZEISS connected laboratory software solution. It includes modules that provide image analysis, data reporting and archiving solutions for images and data acquired with Smartproof 5 and other ZEISS industrial microscopy solutions.
- Shuttle & Find enables seamless relocation of identified regions of interest: from Smartproof 5 to any other light microscope for basic to advanced optical inspection and documentation; from Smartproof 5 to ZEISS scanning electron microscopes for high-resolution surface imaging or elemental composition analysis using energy-dispersive X-ray spectroscopy (EDX).
- ZEN Connect, a module for ZEN core, enables the visualization and reporting of data from multiple modalities, different laboratories, or even different locations, in a single correlative microscopy workspace.
- ZEN Data Storage provides a solution for image data management—for laboratories, across laboratories or even across locations.
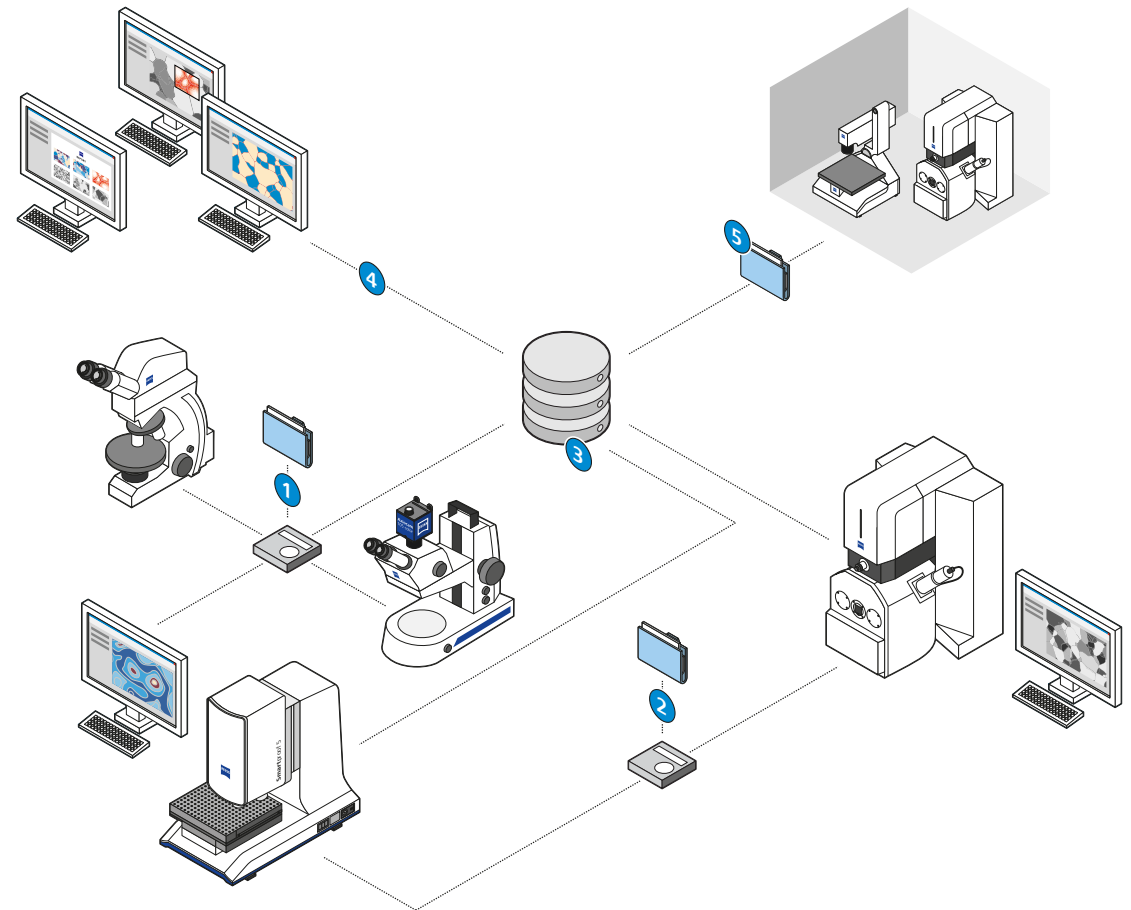

Smartproof 5 in a laboratory environment connected by ZEISS ZEN core:
1) Shuttle & Find between Smartproof 5 and other light microscopes
2) Shuttle & Find between Smartproof 5 and ZEISS EVO scanning electron microscope
3) Central data management enabled by ZEN Data Storage
4) ZEN Connect: image processing, analysis, and reporting on separate office workstations
5) Exchange of images and analysis data, instrument presets, workflow templates, and reporting data between laboratories and locations

Tailored Precisely to Your Applications

| Fields of Application	Typical Tasks and Samples
Automotive and Aerospace	Roughness measurement on bearing, seals, pistons, cylinders, injector nozzles, injection molded or additive manufactured parts
Materials Research / Engineering	Material surface characterization, e.g. fibers, stone, photonic structures, depths measurement after electrochemical etching, corrosion studies, characterization of injection molding processes
Metals and Steel	Roughness measurement and corrosion studies of polished and machined metal surfaces, cutting tools
Electronics	3D topography or roughness on PCBs, IC packages, condensers, solar panels, LED, displays, glass
Medical Industry	Non-contact surface roughness characterization of medical devices and functional surfaces
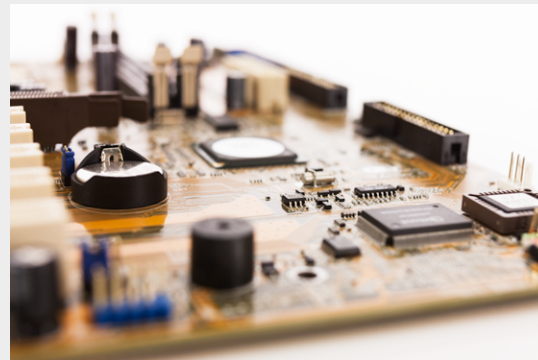
ZEISS Smartproof 5 at Work
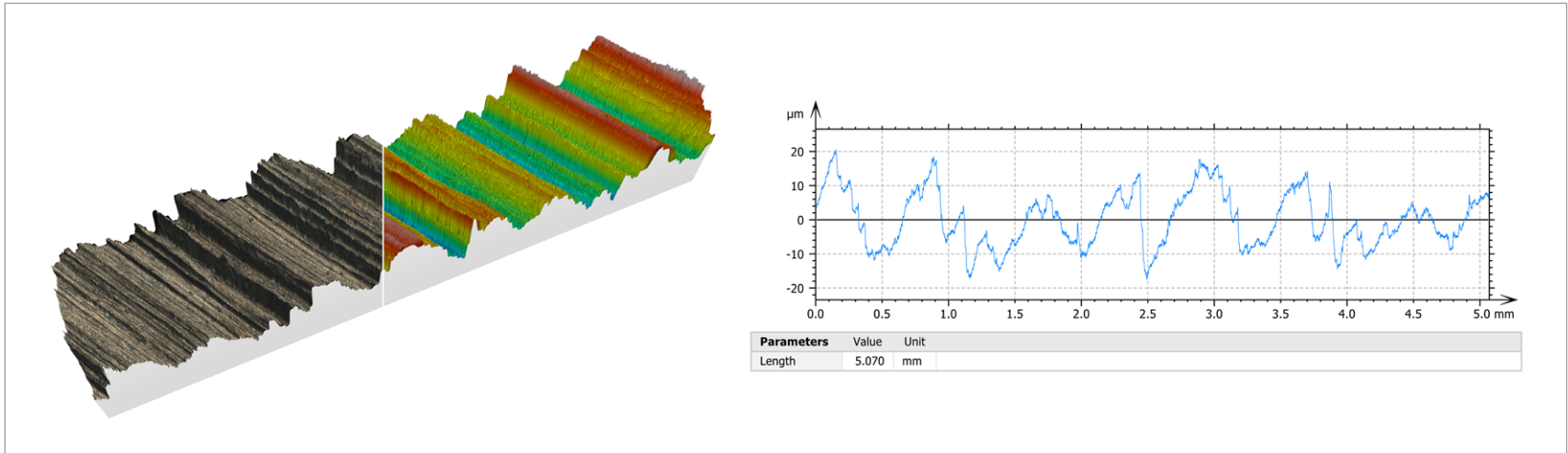
Machined metal surface: (left) 3D view with true color-texture overlay and height map created using a 20×/0.7 objective and four stitched images; (right) roughness profile taken vertical to machining direction shows surface profile.
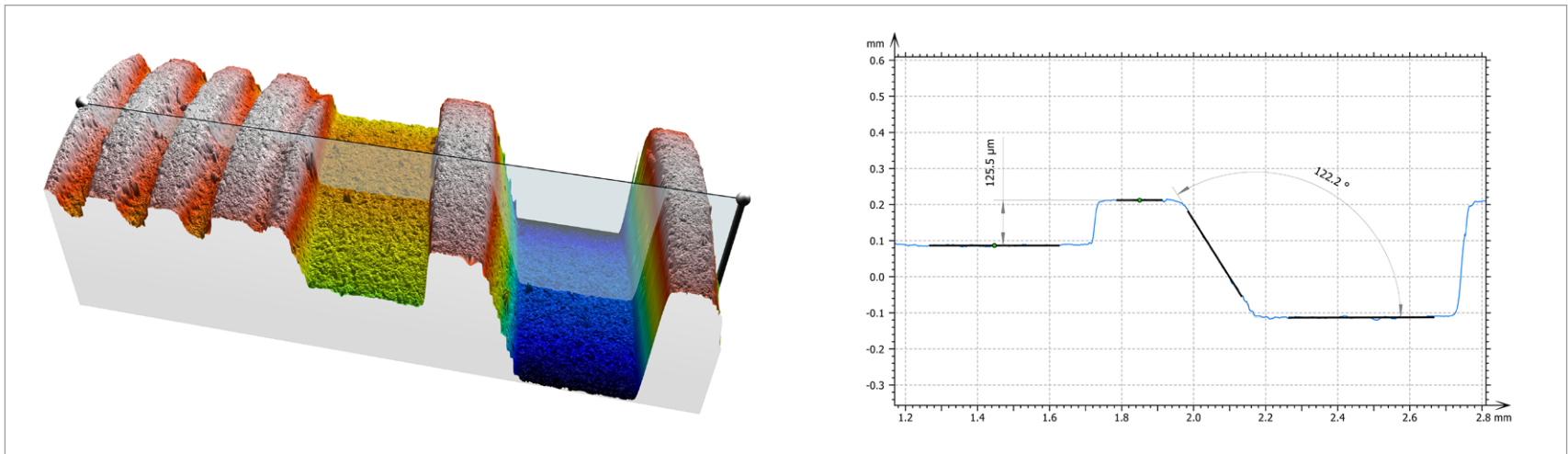

Dental screw: (left) 3D view with color-coded height map; (right) profile taken along indicated direction – see left image – with contour measurements of angles and height difference.

ZEISS Smartproof 5 at Work
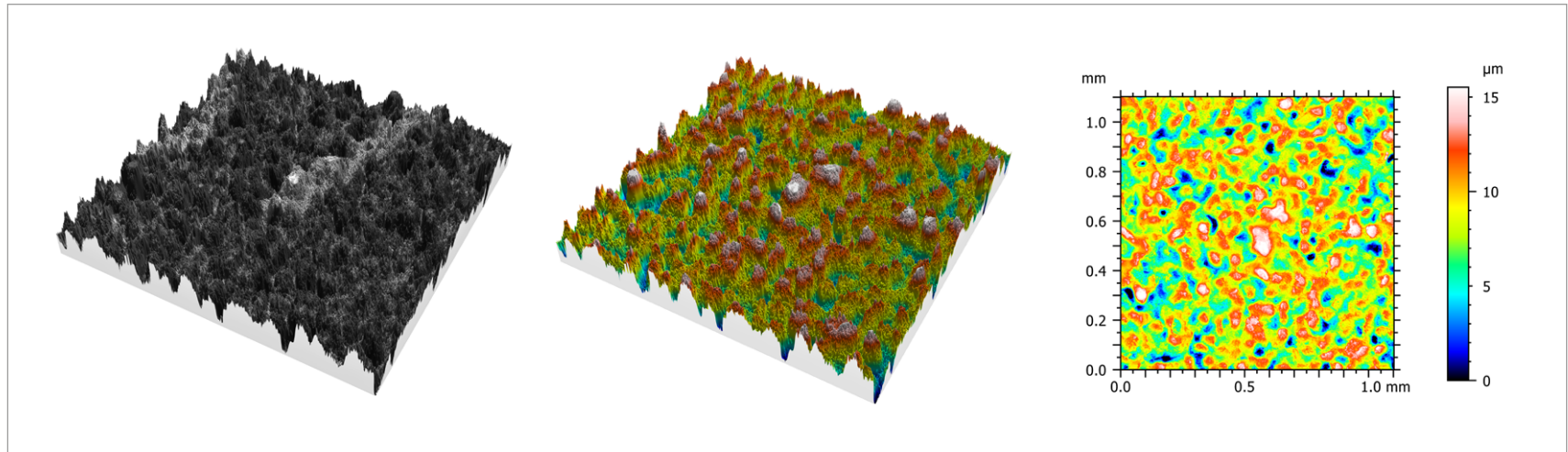
Electronic device: (left) 3D view with true color-texture overlay and (center) height map created using a 10×/0.4 objective; (right) 2D height plot for measuring areal roughness or texture e.g. for quality control purposes or for determining counterfeit electronic devices
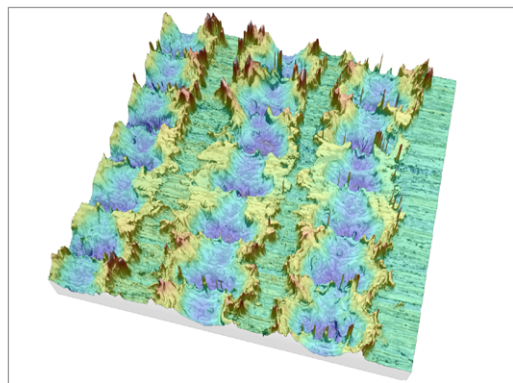
Laser-structured surface, 3D view of color coded height map with texture overlay, C Epiplan-Apochromat 50×/0.95
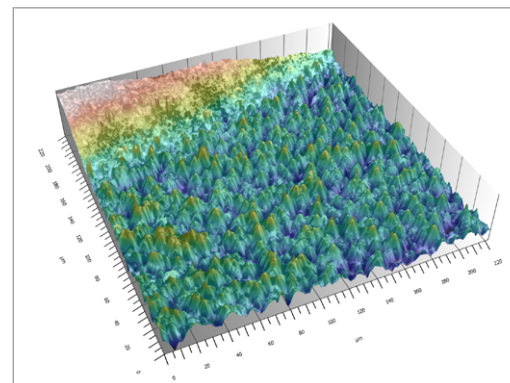
Silver finger on solar cell surface, 3D view of color coded height map with texture overlay, C Epiplan-Apochromat 50×/0.95
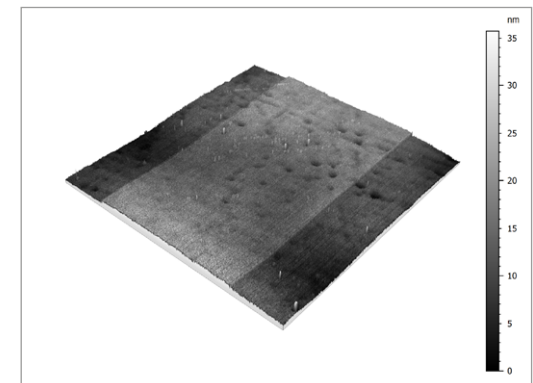
8 nm step height standard, height map, C Epiplan-Apochromat 50×/0.95

Your Flexible Choice of Components

1 Microscope

Smartproof 5 consisting of:

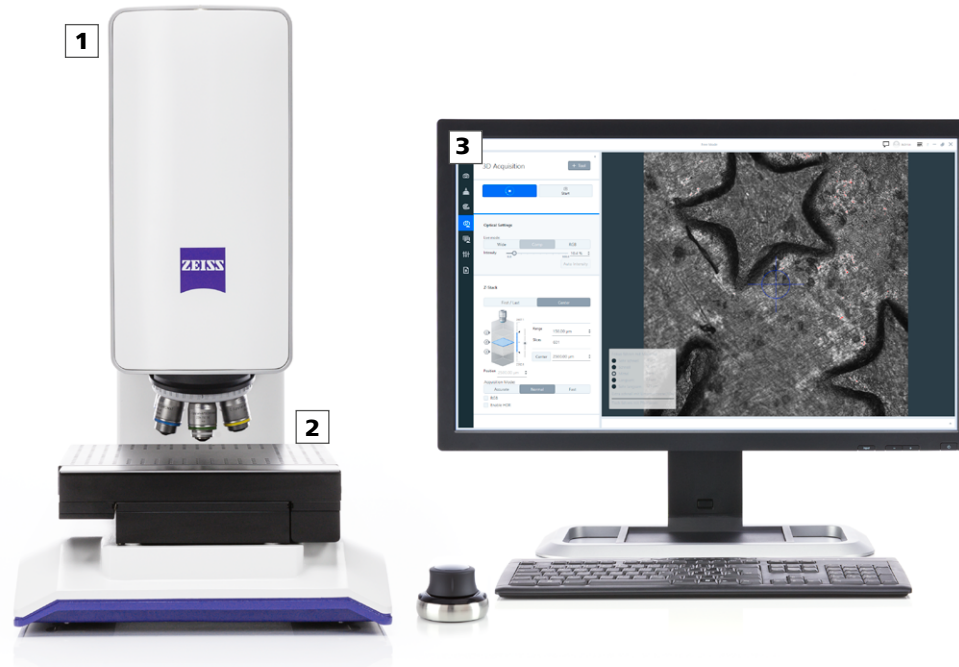- Scan head with fine Z-drive and 4-megapixel camera
- Stand with coarse Z-drive

2 Objectives

- EC Epiplan-Neofluar 2.5x/0.06 (always included)
- C Epiplan-Apochromat 5×/0.2
- C Epiplan-Apochromat 10×/0.4
- C Epiplan-Apochromat 20×/0.7
- C Epiplan-Apochromat 50×/0.95
- LD C Epiplan-Apochromat 50×/0.6 (long working distance)
- LD C Epiplan-Neofluar 100×/0.75 (long working distance)

3 Computer System

- PC system with Smartproof ZEN software
- Monitor
- 3D mouse for control of XYZ axes

4 Software

- ZEN core for data acquisition and imaging
- ConfoMap for data analysis
- ZEN Shuttle & Find for correlative microscopy
- ZEN Data Storage for centralized data management
- ZEN Intellesis for advanced image segmentation
- ZEN Connect for data visualization and analysis of different imaging modalities
- NEO pixel for automated 2D measurements

System Overview
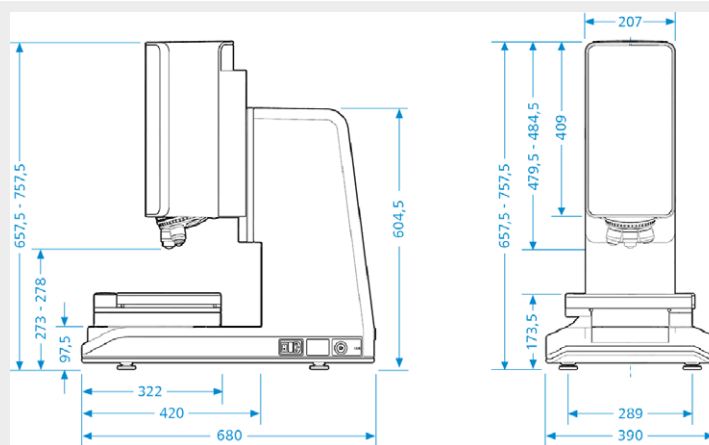
System Components

Optical Unit	Containing the fine Z-drive, the illumination with 405 nm, red, green and blue light, the widefield spinning disc aperture correlation module, 4 megapixel camera and 6 times objective nosepiece.
Objectives	2.5× lens for overview and navigation, 5× to 100× high numerical aperture lenses, specially designed for 405 nm as well as white light.
Stage	Powered by a stepper motor with integrated controller, which makes it possible to move to relevant areas of the sample in a reproducible manner. Alternatively, a fixed stage is available.
Stand	Powered by a motorized Z-drive for sample height adjustment and including controlling electronics.
3D Mouse	Offering intuitive operation of all XYZ axes, including coarse and fine Z-drive
PC	Containing the Smartproof 5 application software and connected to the camera via USB 3 and to the stand via USB 2.

Technical Specifications

Image Field According to Objective Magnification	Objective Magnification and Numerical Aperture	Field of View (µm × µm)	Free Working Distance (mm)
	5×/0.2	2250 × 2250	21.0
	10×/0.4	1125 × 1125	5.4
	20×/0.7	562 × 562	1.3
	50×/0.95	225 × 225	0.22
	50×/0.6	225 × 225	7.6
	100×/0.75	112 × 112	4.0

Image Pixel Resolution	2048 × 2048 pixels
Lateral Resolution (Line-space Pattern) Using 50×/0.95	0.13 µm
Lateral Measurement Uncertainty [1]	±(0.1 µm + 0.008 × L) (or better)
Vertical Measurement Uncertainty [1,2]	±(0.1 µm + 0.012 × L) (or better)
Movement Resolution of Z-Drive	1 nm
Illumination	405 nm LED for confocal imaging and RGB LEDs for color imaging
Camera Frame Rate	50 fps at 2048 x 2048 pixels using USB 3
Color Depth	10 bit
Height Scanning Range	Up to 5 mm
Maximum Height of Work Piece	100 mm
Maximum Weight of Work Piece	5 kg
Scanning Stage Size and Travel Range in X and Y	300 mm × 240 mm 150 mm × 150 mm
Image Data Processing and Measurements	2D: distance, height, angle, constructed elements, profile roughness based on ISO 4287 3D: lateral distances, 3D distance, height, angle, constructed points, area, volume, areal roughness according to ISO 25178 Additional: Alignment, form removal, filters, noise cut, reporting.

Power Requirements

Property	Value
Mains Voltage	100 V AC to 230 V AC (±10%)
Supply Frequency	50 - 60 Hz
Power Consumption	140 W
Protection Class	I
Overvoltage Category	II
Ingress Protection Mode	IP 20

[1] When measuring a standard sample with C-Epiplan-Apochromat 50×/0.95 under setup conditions recommended in the user manual.
[2] When using the "accurate"-mode for acquisition

Count on Service in the True Sense of the Word

By choosing Smartproof 5 from ZEISS, you've put reliability and availability among your top priorities for quality assurance and quality control.

Your Performance. Our Support.
Your Smartproof 5 is designed for a long, productive life. However, should you ever have a question about the technology or how to use it, a dedicated team of experts will be available by phone, e-mail or remote access.

Because Your Standards Are Uncompromising: Service Agreements with Connected Assistance
If you rely on a high level of availability, you are well served by our ZEISS Protect Service Agreements. You can be sure of priority service and shorter response times as well as rapid repairs – and with Protect premium, all of that comes for a flat fee.

Benefit from the optimized performance of your microscope system with services from ZEISS – now and for years to come.

>> www.zeiss.com/microservice

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