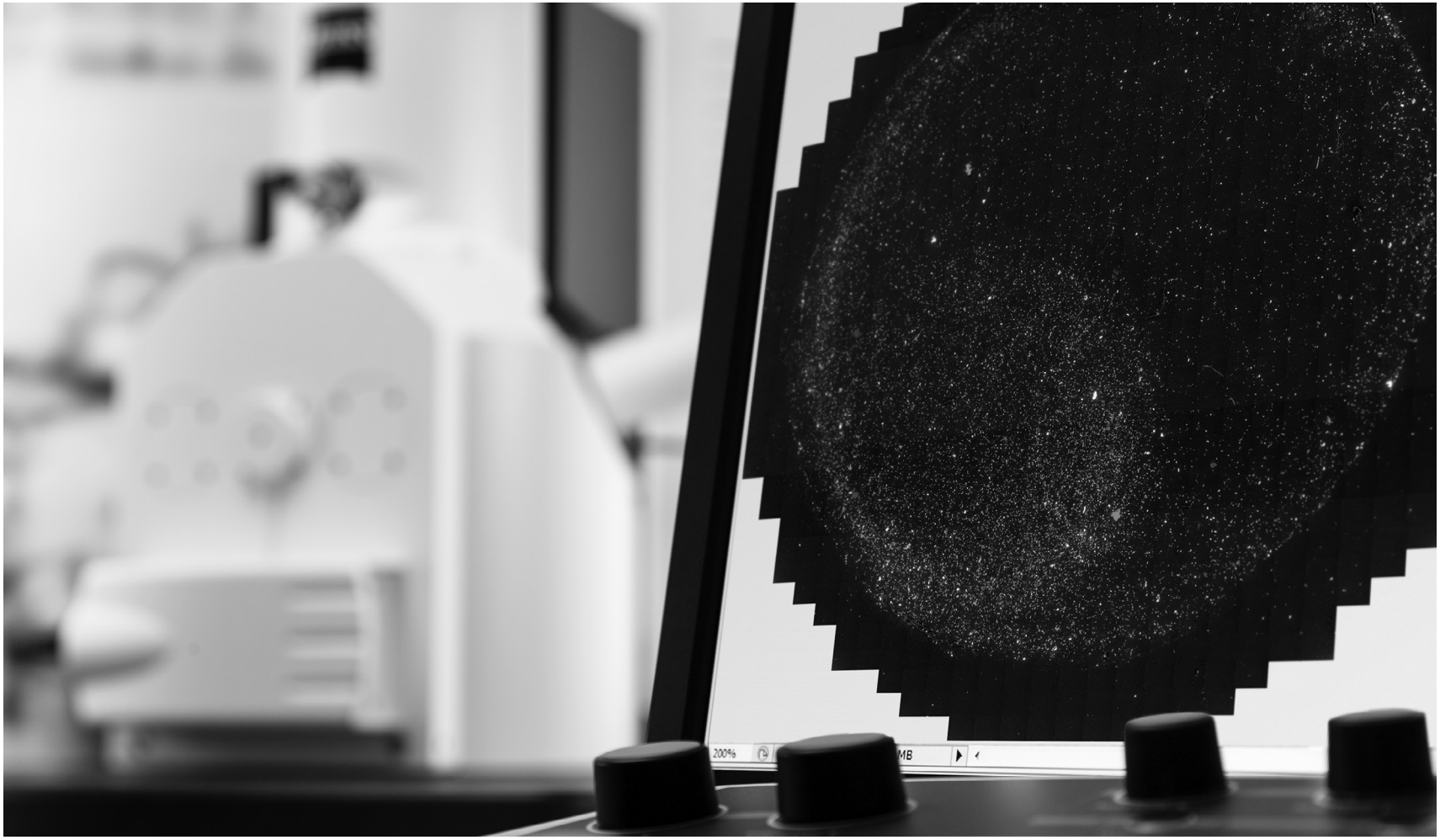

Product Information
Version 1.0

ZEISS SmartPI

Your Automated SEM Particle Analysis and Classification Solution

Detect, Analyze and Classify Particles

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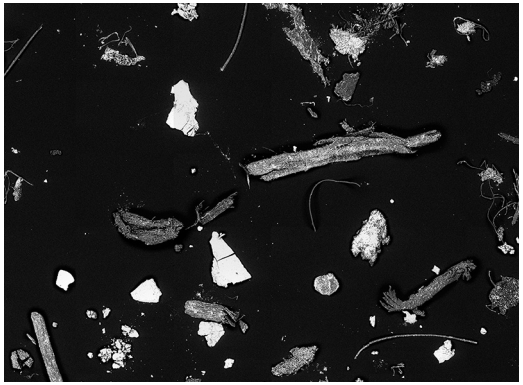
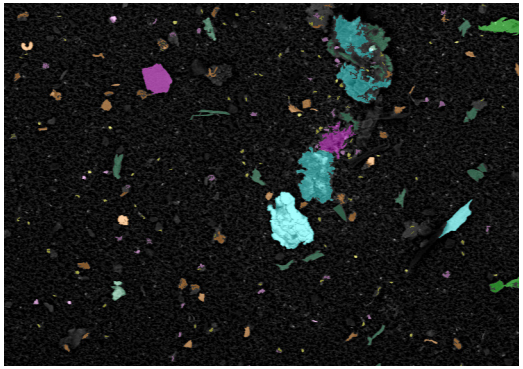
Smart Particle Investigator (SmartPI), your advanced particle analysis and classification solution, turns scanning electron microscopes (SEM) into turnkey solutions for industrial cleanliness or metal and steel applications. SmartPI incorporates all aspects of SEM control, image processing and elemental analysis (EDS) within a single application. SmartPI carries out particle analysis automatically, allowing continuous unattended operation of the instrument, and generating repeatable data—from filter to filter, operator to operator, or laboratory to laboratory. SmartPI is an integrated ZEISS solution that is supported entirely by the global ZEISS service and applications team.



Gray-scale segmentation of particles by backscattered electron intensity



Energy dispersive X-ray (EDS) classification of particles

Simpler. More Intelligent. More integrated.

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The Power of Simplicity

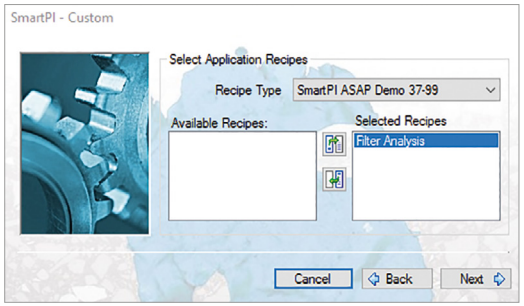
SmartPI automation dramatically simplifies operation so you don't have to be a microscopy expert to get great data. Simply load the sample holder and initiate predefined analysis routines (recipes). At the same time, more experienced operators have the power to easily create or modify recipes and tailor the analysis routines to specific requirements. All recipes, system configurations and particle data are stored in an auditable database for easy data review and export.

Intelligent Particle Detection

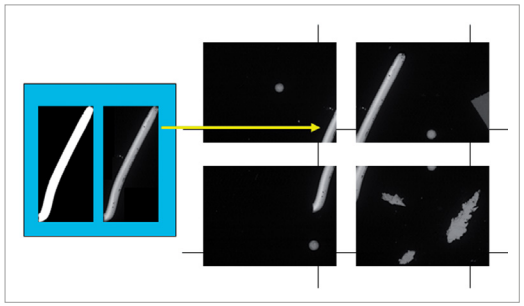
Using a sophisticated border particle stitching algorithm, SmartPI also detects, characterizes and classifies particles that are aligned across multiple fields of view, including truncated particles within the particle dataset. This is particularly important to ensure that larger particles are not dismissed from the statistics, an action that can be detrimental to cleanliness or steel quality analysis. Images of stitched particles can be optionally stored for later review, if required.

A Fully Integrated Solution

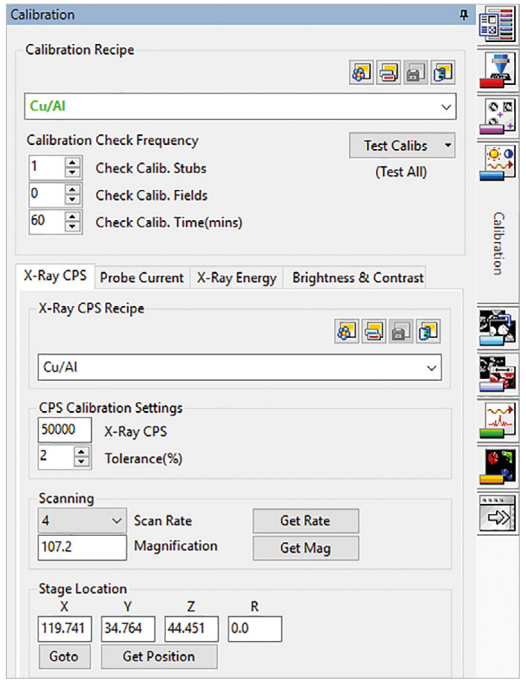
Control both SEM imaging and EDS analysis with one software program on a single PC. ZEISS SmartPI keeps all data together, assuring both SEM and EDS data integrity and efficient data recall. Even when the EDS system is sourced from an EDS supplier, the entire SmartPI system is supported by the global ZEISS service and applications team—keeping all customer care under one roof.



Select predefined analysis routines



Schematic of border particle stitching feature showing composite stitched particle and constituents



Integrated set-up for automated EDS analysis

Tailored Precisely to the Needs of Industry

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Meeting the Demands of Industry
SmartPI was developed in close collaboration with a global supplier of automotive components, who had a specific need for a powerful yet easy to use particle identification and classification system. This means that not only have current industrial cleanliness analysis requirements been taken into account, but also usability concerns are addressed for the typical industrial environment, where not every operator is a microscopy expert, and when solutions are deployed at multiple sites around the globe.

Compliant with the Latest ISO and VDA Cleanliness Standards
SmartPI is compliant with the following cleanliness norms and standards:

- ISO 16232
- VDA 19

Upgradable to Correlative Automated Particle Analysis (CAPA)
Combine SmartPI with a ZEISS light microscope particle analyzer to configure a correlative particle analysis workflow (CAPA) when this need may arise. This option not only increases throughput of a typical “special” particle analysis workflow, but also allows you to combine LM and SEM particle data for advanced particle query and classification. SmartPI from ZEISS leaves this option open all the time should your cleanliness applications evolve over time, for example, transitioning from powertrain to electronics cleanliness requirements.

CAPA sample holder

Correlative Particle Analysis

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More Insights to Particle Origin

Characterize process-critical particles and identify killer particles using Correlative Automated Particle Analysis (CAPA), which combines your data from both light and electron microscopes. First detect particles with your light microscope. Then relocate reflective particles automatically in your ZEISS SEM and perform an EDS analysis to reveal their elemental composition. Use the gallery to query your combined particle analysis dataset, and determine particle origin.

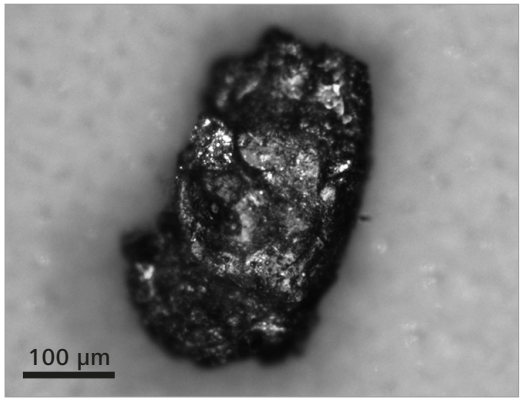
Automated and Fast

With CAPA you automatically get an integrated report showing results from both light and electron microscopy. Additionally you can choose to combine these results in an interactive summary. Get your results up to ten times faster with CAPA versus consecutive individual analysis with light and electron microscopy.

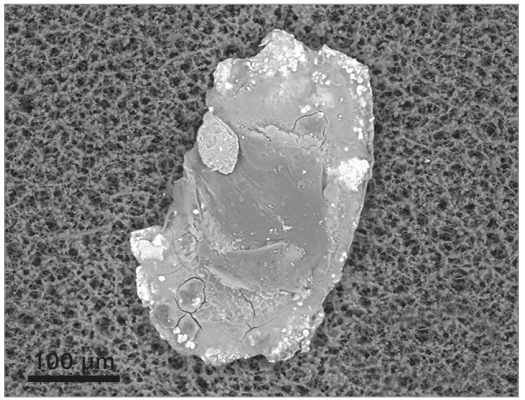
Light Microscope Particle Analysis

Also explore ZEISS' light microscopy turnkey particle analysis solutions, for particle sizes of >25 micron, >5 micron or >2 micron. The particle analysis module in our Axiovision imaging software lets you edit project information, create reports, archive your results, and see all classifications and ISO codes at a glance.

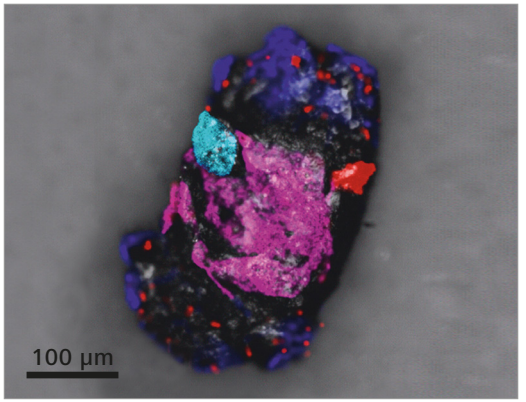
With the gallery and evaluation view, you gain a quick overview to the particle types: reflective, non-reflective, and fibrous. With additional reference data in hand, you can now easily relocate interesting particles at the touch of a button, then use the revision mode to reclassify particles or edit particle data.



Light microscopy image of a metallic particle



Backscattered electron microscopy image of the same particle



Correlation of the light microscope image with the EDS elemental analysis from the SEM

ZEISS SmartPI at Work: Typical Workflow

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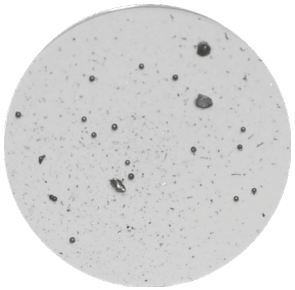
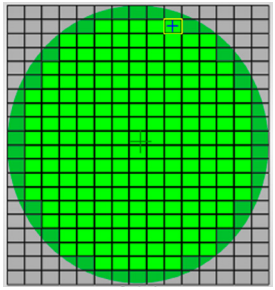
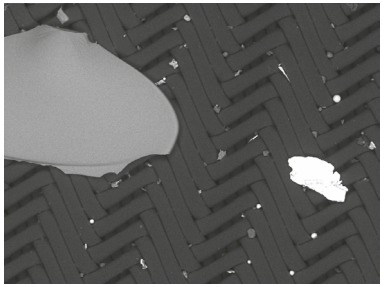
SmartPI Workflow



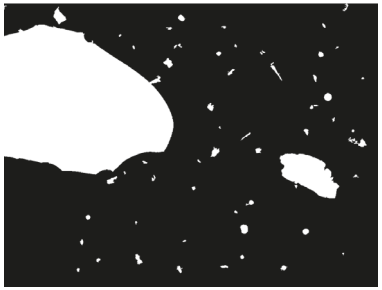
1 Example Filter



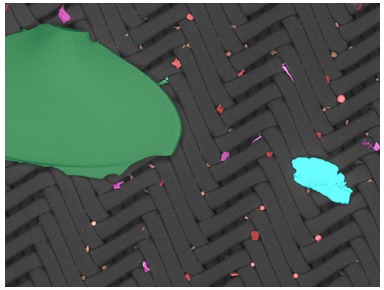
2 Analysis Start of Several Tiles



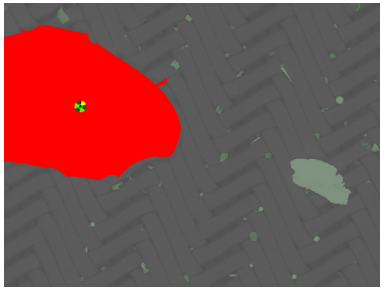
3 Image Aquisition



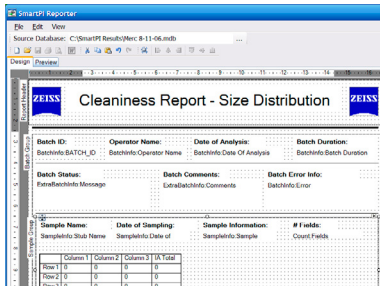
4 Feature Detection



5 Automated Segmentation



6 EDS Classification



7 Report

ZEISS SmartPI at Work: Industrial Cleanliness

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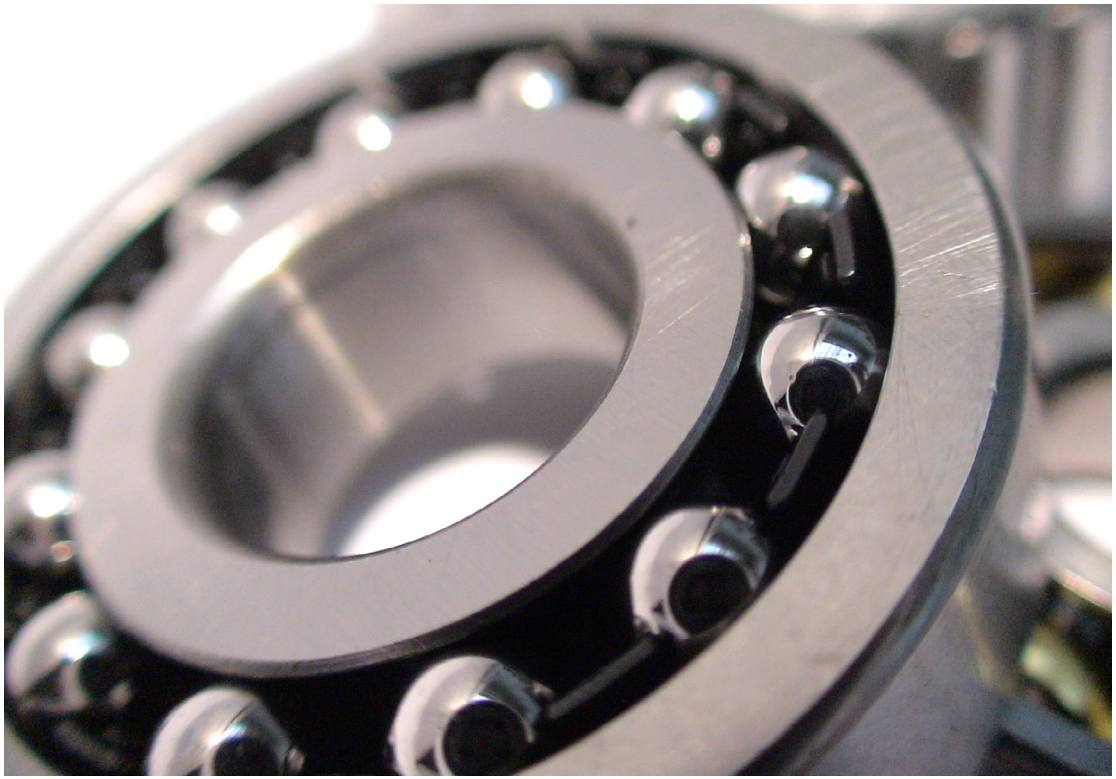
Manufacturing Cleanliness

Cleanliness of parts or assemblies is a critical requirement, for instance, for the subsequent processing of functional surfaces, or to prevent wear or other damages resulting from the accumulation of debris originating from the manufacturing process. Cleaning processes are supported by cleaning equipment and the subsequent analysis of residual particles that remain on parts or in assemblies even after the cleaning process. To ensure consistency of the assessment of residual cleanliness from part to part, operator to operator or even location to location, the method of particle analysis by microscopy is regulated by ISO 16232 and VDA 19 analysis norms and standards.

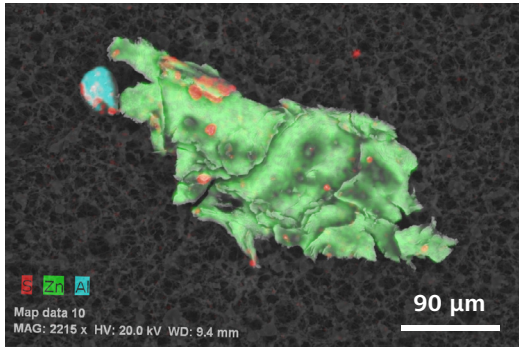


Ball bearing

Light and Electron Microscopy Particle Analysis Solutions

ZEISS offers a range of ISO 16232 and VDA 19 compliant particle analysis solutions using both light, and electron microscopy:

- SteREO Discovery.V8 with Particle module in Axiovision imaging software, for particles from 25 micron in size
- Axio Zoom.V16 with Particle module in Axiovision imaging software, for particles from 5 micron in size
- Axio Imager 2 with Particle module in Axiovision imaging software, for particles from 2 micron in size, and particles filtered from oil.
- Smart Particle Investigator (SmartPI) on EVO scanning electron microscope, for elemental analysis assisted particle classification
- Correlative Automated Particle Analysis (CAPA), combining particle data from light and electron microscopy in a single, coherent dataset.



Elemental distribution in a metallic particle.

ZEISS SmartPI at Work

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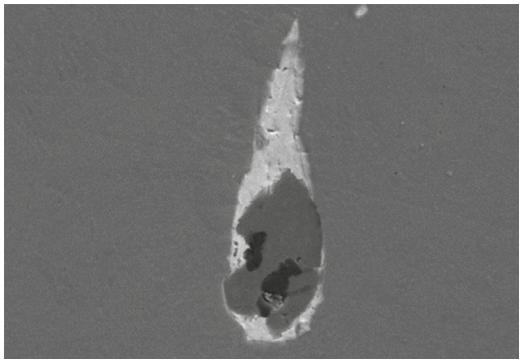
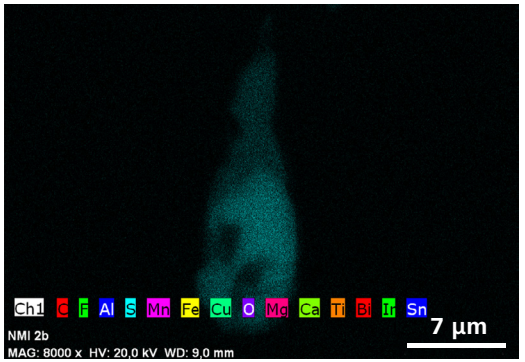
Steel Industry

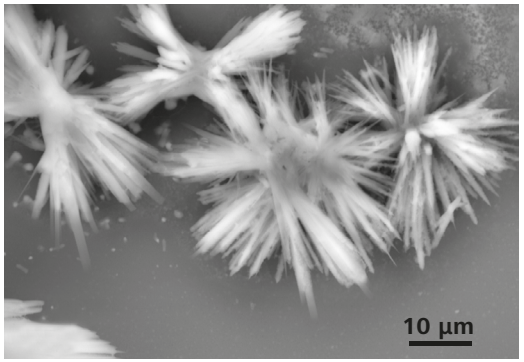


Percipitates in steel.



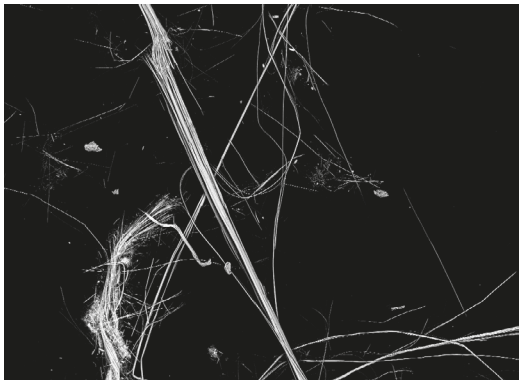
EDX measurement – sulfur content identified.

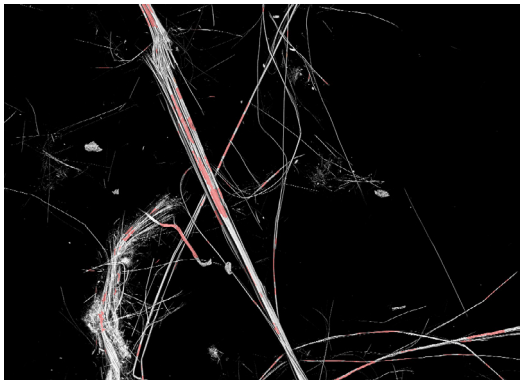
Pharmacy



Drug crystals.

Construction Industry





Particles and fibers from a construction site, including dust, wood and fibers from insulation materials. Asbestos particles identified by EDS indicated by colors in the right image.

Recommended SEM Platforms

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Recommended SEM platforms which are best suited for SmartPI applications

EVO is the conventional (thermal emission) SEM of choice for use in routine materials analysis or industrial quality assurance and failure analysis. With a large motorised 5 axis stage, and easy-to-use SmartSEM software, EVO offers a highly configurable imaging platform for particle analysis applications. EVO is available with variable pressure (VP), enabling the imaging and analysis of non-conductive samples, such as filters, without the necessity to apply a conductive coating, and thus leaving the filter intact for subsequent analysis using e.g. Raman or FTIR.

Sigma 300 is the SEM of choice for users which require enhanced resolution for particle analysis in the nanometer scale range. Sigma featuring Gemini column technology, provides outstanding imaging and analytical results from a field emission scanning electron microscope (FE-SEM). The Gemini optics provides the highest resolution imaging on a platform very well suited for elemental analysis, particularly on magnetic samples.

Sample Holders

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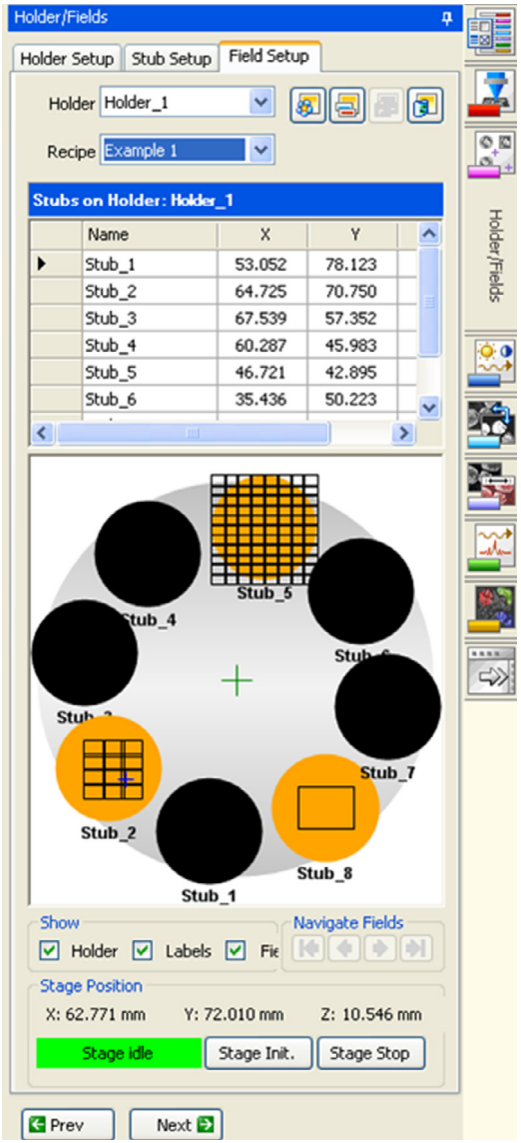
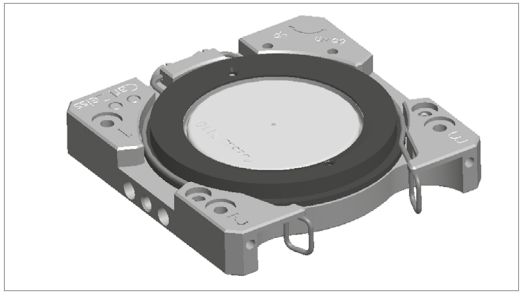
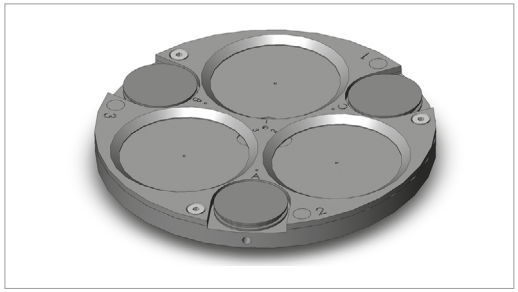


Sample holder setup page

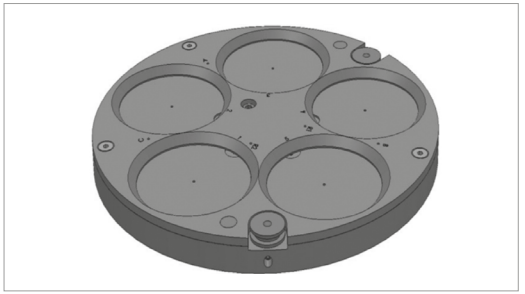
Sample holders include a single filter holder for individual particle investigations; and multi-sample holders for for up to nine filters or stubs, typically used for unattended measurements over hours or even days.



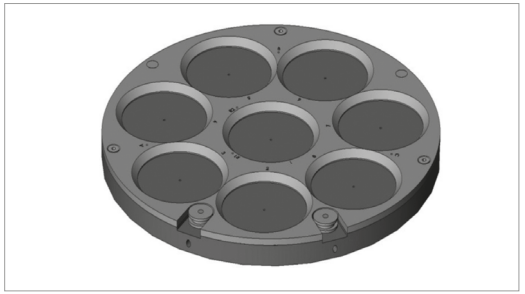
Single filter holder (also used for CAPA)



3 × 47 mm filter holder assembly



5 × 47 mm filter holder assembly



8 × 47 mm filter holder assembly

9 Stub holder assembly

Setup and Calibration

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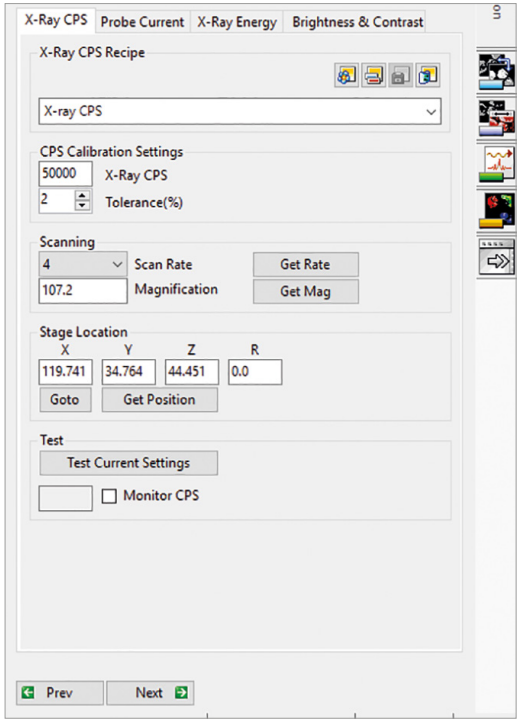
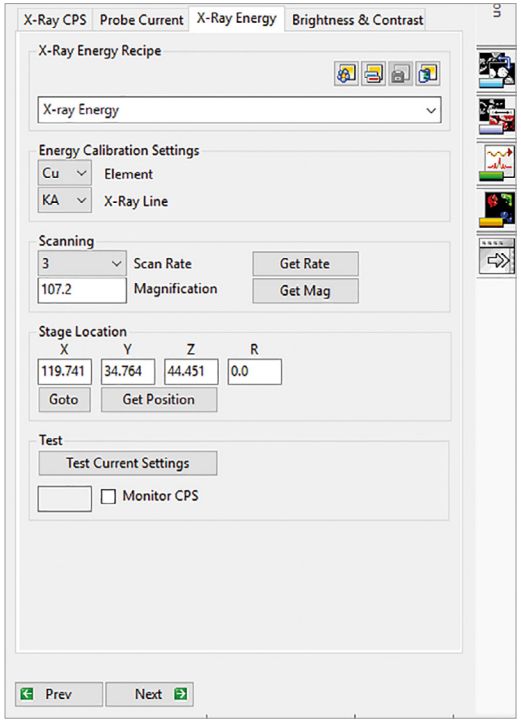
Auto-calibration Procedures

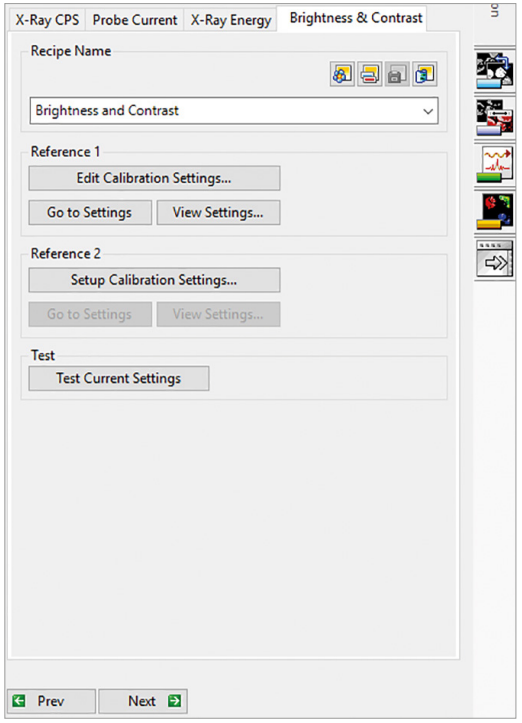
SmartPI performs self-diagnostic and auto-calibration routines before each auto-run and periodically during the run. This ensures system stability, and accurate, repeatable results. Should an interruption occur during the auto-run, for example when a filament replacement is required, an auto-recovery process is initiated.



Setup of EDS count rate



Energy calibration of EDS detector



Calibration of SEM brightness and contrast

Image Acquisition and Analysis

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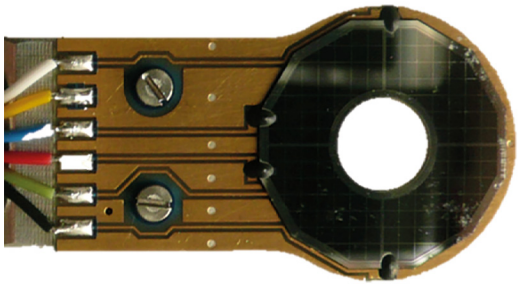
Backscattered Electron Detector

The 4 quadrant, solid-state backscattered electron detector detects particles as shades of higher gray intensity relative to the organic filter substrate. Furthermore, the backscattered electron detector will differentiate between particles of different elemental density, also as different shades of gray. A mosaic of backscatter electron images covering the entire filter will be acquired.

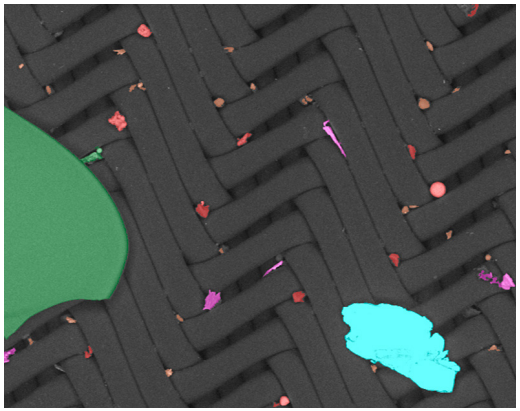
Automated Image Analysis

Concurrently, image analysis will be performed on all the images. Depending on the application and type of particles, a wide range of measurement parameters can be included in the automated analysis, such as:

- Area
- Average gray level
- Breadth
- Center of gravity X
- Center of gravity Y
- Chord count
- Compactness
- Effective diameter
- Elongation
- Convex perimeter
- Feret elongation
- Feret max angle
- Fiber length
- Maximum inscribed circle
- Maximum perpendicular cross-section
- Feret max diameter
- Feret mean diameter
- Feret min angle
- Feret min diameter
- Feret X
- Feret Y
- Length
- Min X
- Max X
- Min Y
- Max Y
- Perimeter
- Roughness



The 4-quadrant backscattered electron detector



Particles can be classified by size and shape

Elemental Analysis

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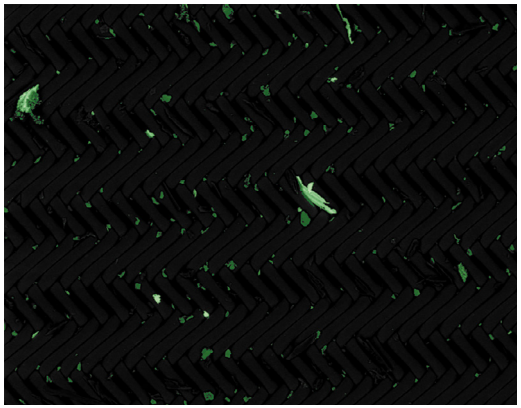
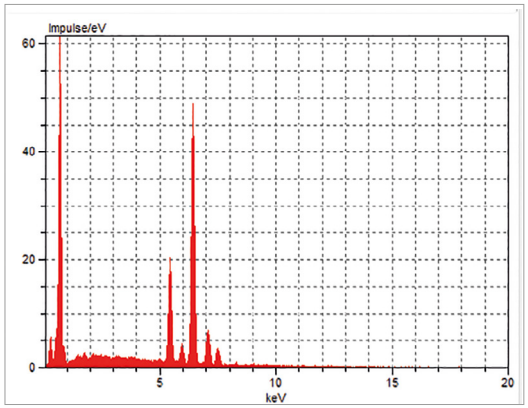
Morphological and Chemical Classification

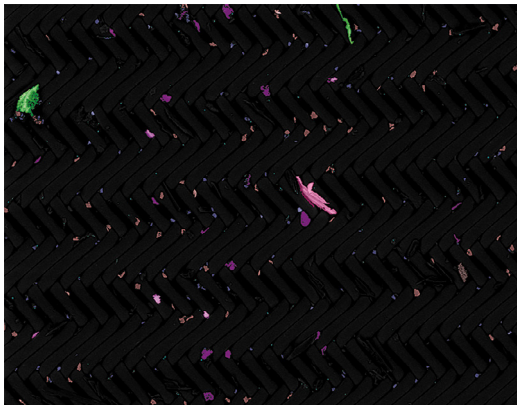
SmartPI employs advanced image processing and analysis techniques to measure a variety of morphological characteristics for each particle detected. Subsequently, EDS analysis is used to determine the chemical composition of each particle. Analyze particles rapidly with either Spot Mode or in more detail using the advanced ZEISS Feature Scan Mode. This scans the complete particle shape to provide a more accurate classification.



Morphological segmentation of particles



EDS spectrum view



Chemical classification of particles

Balance Statistics with Run-time

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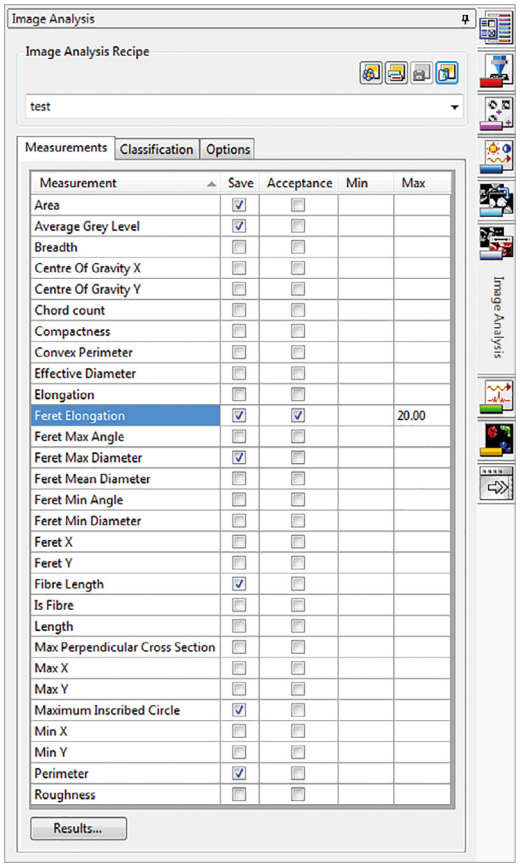
Measurement Exclusions

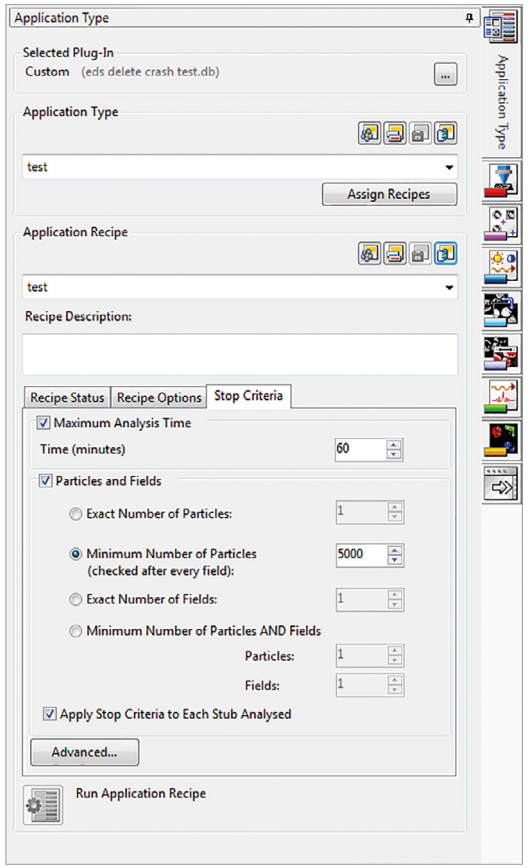
In order to keep your particle dataset coherent and minimize runtime, SmartPI enables you to exclude particles, that are not deemed of interest, from subsequent image and elemental analysis. This could, for instance, be the case for elongated fibers on the filter that may originate from dust in the environment, and hence are unrelated to particles originating from the manufacturing process.

Advanced Stop Criteria

A range of advanced stop criteria allow the auto-run to end the analysis when it reaches a predefined threshold. Stop criteria can include analysis time, number of particles or fields counted, particle size, a specific classification, or other criteria that you can specify. This feature can be applied to single or multiple samples, thereby significantly reducing the overall run-time. A live results window also allows the operator to monitor the progress and decide whether any intervention is required.



Exclusion of fibers, for example, via limitation of the parameter elongation



Stop criteria setup page

Interactive and Retrospective Particle Classification

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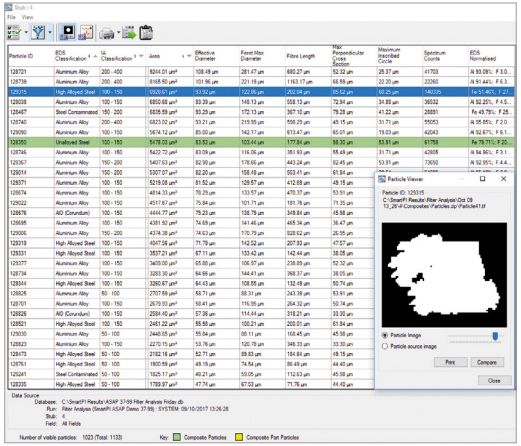
Review Output Mode

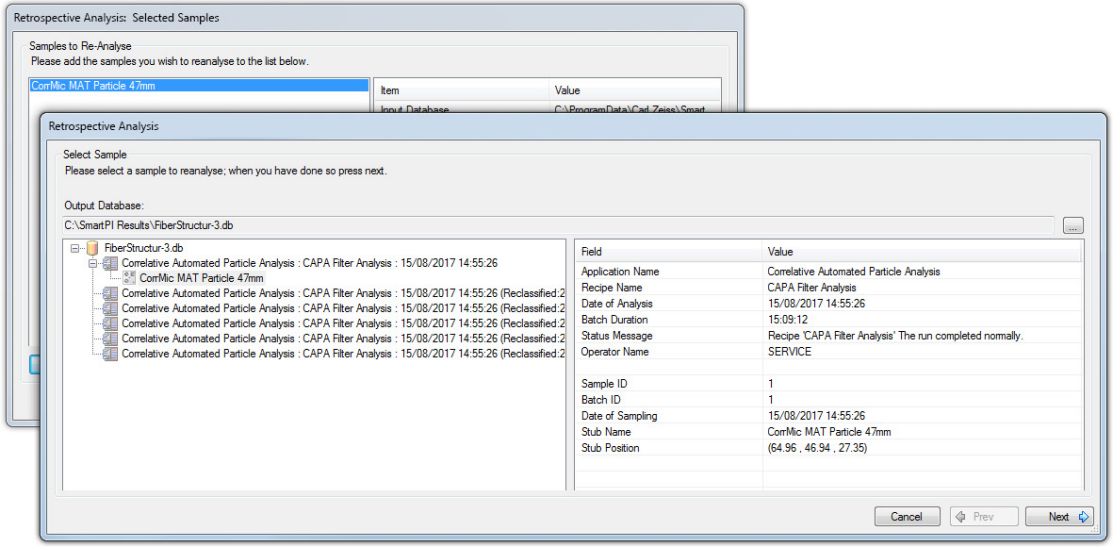
Use this mode to refine and improve the classification recipes by making a detailed examination of the results. You can also re-examine any particle by returning the stage to the appropriate particle coordinates.



Use the review mode to re-examine single particles and see all of their properties including EDS composition and material classification..

Retrospective Analysis

This mode lets you re-evaluate existing results by using new classification criteria—without the need to re-analyze the sample.



Select a new recipe for a retrospective analysis

Viewing and Reporting

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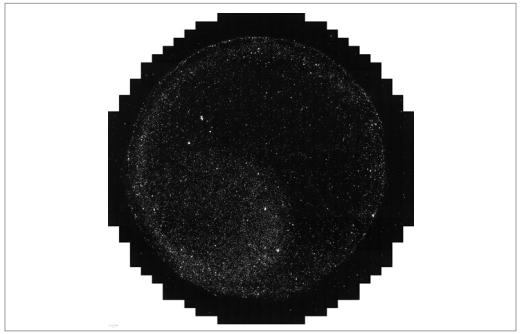
SmartPI Explorer

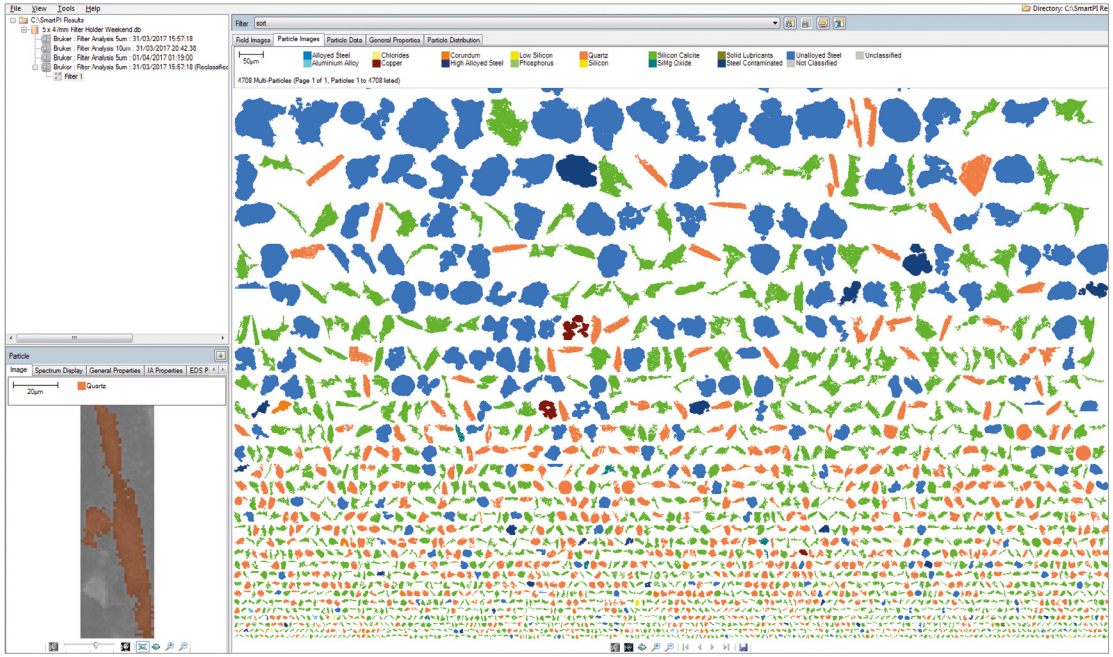
This standalone application lets you browse or search the results for individual spectra, particle images, field images, border particles, or other filters you select. In addition, SmartPI Explorer includes options for archiving, as well as an image montage feature for creating a stitched image from the fields analyzed. Explorer also may be used offline to free up system time for analysis.



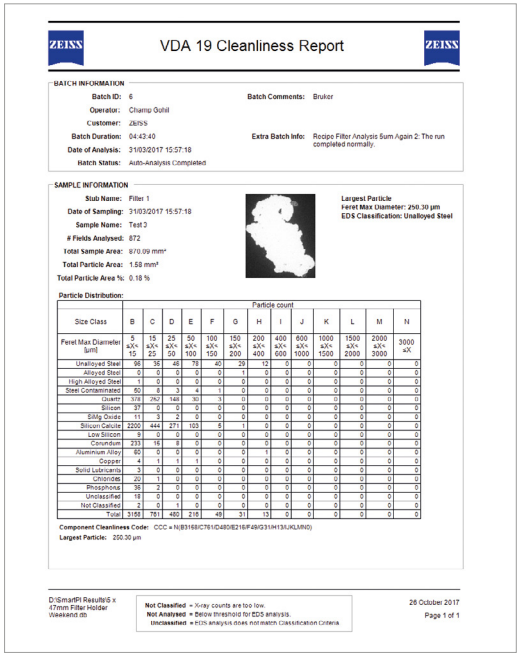
Montage of the whole filter stitched from several fields

SmartPI Reporter

This standalone application has a number of built-in tools which allow you to construct dedicated reports. You can use drag-and-drop controls, modify an existing report template, or select an ISO or VDA standard report. Once you've defined your report, you can save it as a template for future reports. Use SmartPI Reporter online for immediate report generation or offline when you will be analyzing results at a later time.



SmartPI Explorer navigation window with multi-particle view



VDA 19 cleanliness report generated in SmartPI Reporter

Technical Specifications

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Parameter	Specification
Hardware	EVO, SIGMA 300
Software	Compatible with Windows 7 and Windows 10: SmartPI, SmartPI Explorer, SmartPI Reporter
	Compatible with a range of Bruker and Oxford silicon drift detectors
Minimum size of particles	approximately 20 nm (steel)
Maximum number of particles	500,000 particles
Repeatability	For image acquisition parameters like FeretMax: 97%
Special features	Border particle stitching, SEM and EDS software in one software interface, CAPA upgradability
Capabilities	Stop criteria, fiber measurements, morphological and chemical analysis, auto calibration procedure
Samples	Measurement of up to 8 filters or 9 stubs in one run
Standards	ISO 16232, VDA 19

Count on Service in the True Sense of the Word

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Because the ZEISS microscope system is one of your most important tools, we make sure it is always ready to perform. What's more, we'll see to it that you are employing all the options that get the best from your microscope. You can choose from a range of service products, each delivered by highly qualified ZEISS specialists who will support you long beyond the purchase of your system. Our aim is to enable you to experience those special moments that inspire your work.

Repair. Maintain. Optimize.
Attain maximum uptime with your microscope. A ZEISS Protect Service Agreement lets you budget for operating costs, all the while reducing costly downtime and achieving the best results through the improved performance of your system. Choose from service agreements designed to give you a range of options and control levels. We'll work with you to select the service program that addresses your system needs and usage requirements, in line with your organization's standard practices.

Our service on-demand also brings you distinct advantages. ZEISS service staff will analyze issues at hand and resolve them – whether using remote maintenance software or working on site.

Enhance Your Microscope System.
Your ZEISS microscope system is designed for a variety of updates: open interfaces allow you to maintain a high technological level at all times. As a result you'll work more efficiently now, while extending the productive lifetime of your microscope as new update possibilities come on stream.

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

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