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# Automated Desktop SEM Analysis

## Discover failures early to meet your quality targets and save time

ThermoFisher SCIENTIFIC

# Introduction

Using today's powerful scanning electron microscopes (SEMs) to explore minute portions of matter, materials scientists can gain a deeper understanding of the structure and composition of materials, while learning how these materials are influenced by their surrounding environment.

For industrial manufacturers, SEMs can help improve the quality control process, ensuring that only the highest-quality materials, components, and products make it into the hands of customers. By analyzing the topography and composition of their products, quality control managers can pinpoint contamination, fractures, inclusions or defects and then use this information to make changes to the production process.

Yet while SEMs serve as an important quality control tool, operators are often required to examine hundreds of images collected from numerous samples, which makes for repetitive, time-consuming work.

By automating repetitive SEM processes, companies can analyze high volumes of samples with less human error, ensuring they meet quality standards easier, faster, and with greater precision. They can discover failures early, obtaining the quality information they need to quickly adjust their production processes before costly delays occur. They can save unnecessary waste generated from inferior raw materials and deficient finished products. And they can eliminate manual, repetitive tasks—freeing up time for value-added work.

**Continue reading to learn how to automate your quality control process today to reduce costs and increase output**

# Reasons to Automate

Ever since scanning electron microscopes (SEMs) first became popularized, there's been an accompanying desire to automate. With all the manual, repetitive steps required to study samples at the microscopic level, scientists have sought to improve the efficiency of these processes.

As the technology behind SEMs continues to mature, the skills required for their use has become more sophisticated. Researchers must now grapple with more intricate tools for sample preparation, more complex algorithms for image processing, and increasingly large data sets for analysis. At the same time, users from a broader range of fields are turning to electron microscopy for their research, many of whom lack advanced microscopy skills. All of these factors have increased the demand for automation.

Today, the desire to automate is generally motivated by three goals : the need to eliminate human error, the desire to save time and money, and the difficulty of finding needle-in-the-haystack particles.

## Eliminate human error

When a person sits in front of a system and examines an SEM image, it's natural for the eye to gravitate to the characteristics that stand out. But there may be many other important features that the researcher doesn't see. This problem is exacerbated by human error, making it difficult to get results that are statistically relevant. By automating, researchers can be sure nothing is missed, without compromising the reliability and repeatability of their data.

## Save time and money

Whether it's taking hundreds of images of the same sample or analyzing thousands of data points for a quality control process, repeating the same steps over and over is time-consuming. Not only does it unnecessarily increase labor costs, but it restricts the use of the microscope for other purposes. By automating everything from image acquisition to data collection and analysis, researchers can dramatically increase their output, reducing costs and freeing up their already busy schedules.

## Locate needle-in-the-haystack particles

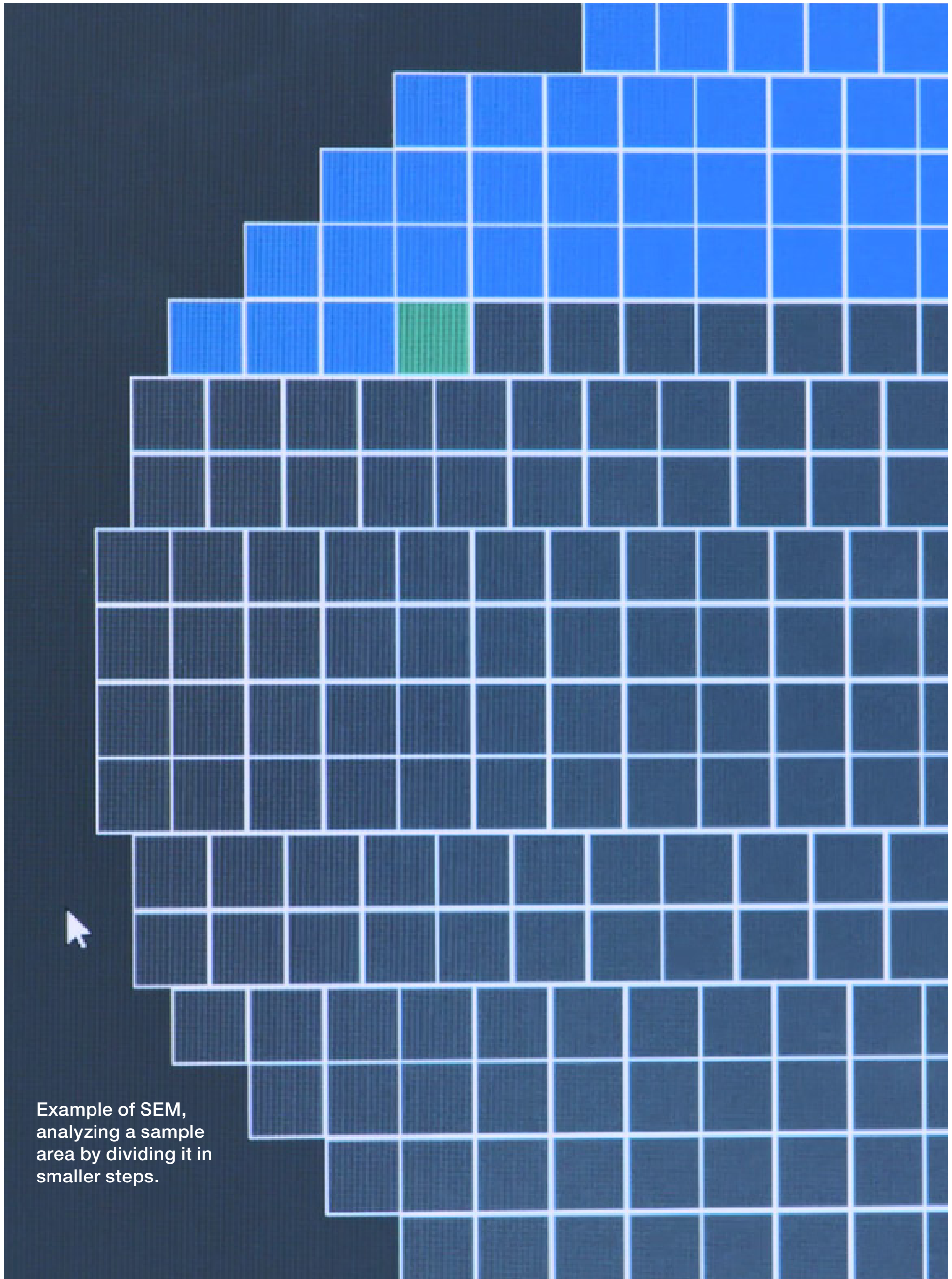
For many analyses, scientists seek to find a specific particle within a large area of particles, much like searching for a needle in a haystack. A common example is gunshot residue analysis, where technicians analyze a sample for gunshot residue particles in order to determine if a firearm was discharged at a crime scene. Not only is the manual process time-consuming, but it is prone to human error. By automatically examining a large number of samples, researchers can speed up their analyses, while obtaining more reliable results.

# Levels of Automation

## How much you automate and which SEM processes you choose depend on the specific needs of your organization and the repetitive tasks you face.

It may be that operators are manually taking hundreds of images of the same sample and then stitching them together to obtain a single large image of the sample. Perhaps they're manually combining secondary electron (SE) and back scattered electron (BSE) images to combine topographical and compositional information. It could be that they're manually searching for tiny contaminants within an otherwise uniform sample. By analyzing which repetitive steps require the most time and present the greatest risk of human error, organizations can determine where automation will provide the biggest value for their investment.

In general, the level of automation an organization chooses can range from basic to advanced, depending on the complexity of the tasks at hand.

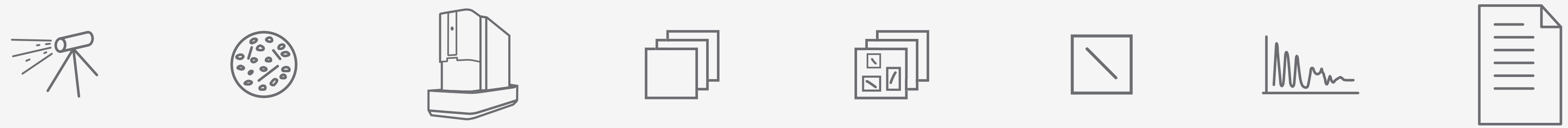


Example of SEM, analyzing a sample area by dividing it in smaller steps.

# Levels of Automation - Basic

## Basic automation

In some cases, users require just a basic level of automation that may still involve some human operation. A great example is detecting the presence of asbestos, a naturally occurring silicate mineral often used in construction. Due to the fact that asbestos is a hazardous material, standards must be followed for assessing the risks of exposure. Depending on the sampling time, a user might be required to analyze more than 100 image fields, and capturing these fields is a repetitive process.



**1** During sampling, a known volume of air is drawn through gold-coated, porous filters.

**2** Filters are checked for damage by the analyst.

**3** Samples are loaded into the SEM equipped with an EDS detector.

**4** About 100 images are acquired at random, non-overlapping positions on the filter.

**5** On each image, fibers are detected based on morphological parameters: length, width and aspect ratio.

**6** Fibers can be revisited for manual inspection by the analyst.

**7** By analyzing the EDS results, the analyst can verify whether a fiber was asbestos, and classify the fiber by asbestos type.

**8** A report of the counted fibers can be generated automatically when the analysis is finished.

**Schematics of the workflow of asbestos analysis as described in the ISO 14966 norm.**

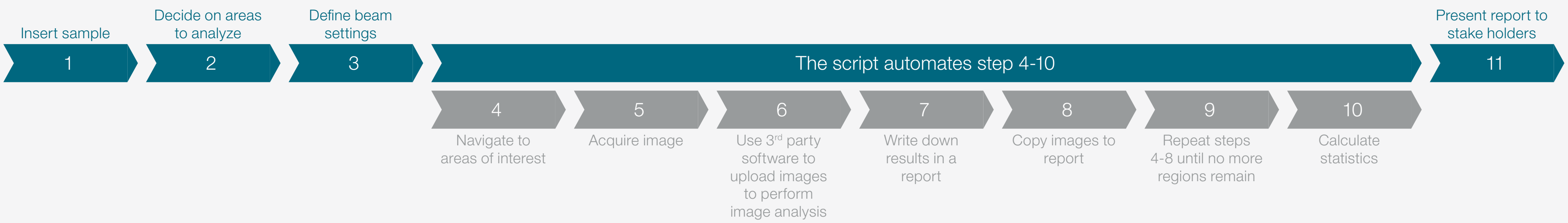
By setting up a simple automated script to help them with their asbestos analysis, operators can specify the number of images that the script should acquire, whether they're adjacent or not, before manually inspecting them for asbestos fibers. The images are then automatically saved so the operator can perform an energy-dispersive X-ray spectroscopy (EDS) analysis to get the chemical composition of the suspect fibers. When the analysis is over, the overall asbestos content is evaluated and compared to standard values defined by norms. If the asbestos concentration is over a certain value, it is necessary to intervene with highly specialized removal procedures.

# Levels of Automation - Intermediate

### Intermediate automation

In some cases, organizations may want an intermediate level of automation that involves the combination of several SEM functionalities. One example is ensuring the quality of protective coatings applied to materials. In the automotive industry, for instance, phosphate conversion coatings are used to prevent corrosion of steel parts, while enhancing lubricity. The coating is applied by immersing the part in a solution containing phosphorous acid and a metal phosphate. As a result, a crystalline layer of zinc, manganese or iron phosphate is deposited on the steel component.

To ensure the efficacy of the phosphate conversion coating process, suppliers to the automotive industry need to perform stringent quality control. An SEM is of great use for assessing the coverage percentage of a phosphate coating: BSD images emphasize elemental contrast. Steel appears bright on a BSD image, but becomes dark when it is covered in a phosphate layer. However, analyzing SEM images manually is extremely laborious, and subject to human error.




**Process flow of the automated tool for the quality check of the phosphate coatings coverage.**

With an automated script, users can define criteria for identifying defective samples—say, samples with less than 95 percent coating. Large areas of the sample can be automatically scanned, before images are automatically analyzed to determine the coverage percentage, with the results compiled into a report to be later reviewed by the user. While automating the quality control process for coatings requires an intermediate level of scripting, once the script is completed, the quality check can be performed without human operation. Operators can run the quality check at any time and review the report at will—saving valuable time and improving the reliability of their results.

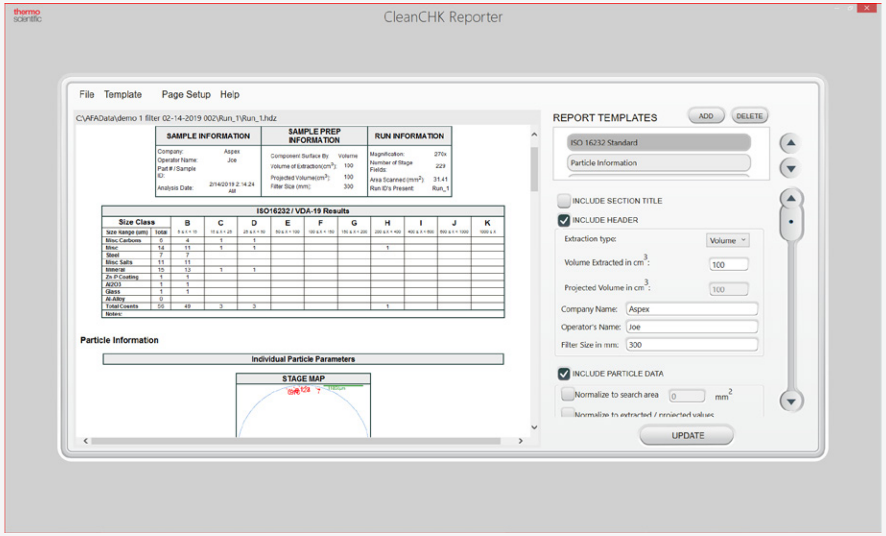
# Levels of Automation - Advanced

### Advanced automation

In other cases, users require advanced automation, as in the case of technical cleanliness. In the automotive industry, for example, components such as automatic transmissions use precision manufactured electro-hydraulic components that cause the transmission to degrade as the result of even the smallest amounts of dirt or debris. To ensure the cleanliness of their parts, automotive suppliers must comply with stringent cleanliness standards such as VDA19 and ISO16232. Historically, production engineers have used an SEM in combination with energy dispersive X-ray spectroscopy (EDS) to provide cleanliness data for automotive components. Such processes are extremely laborious, typically require specially trained users, and can lead to delays in production.

Using today's advanced automation, users can perform automatic analyses that combine SEM and EDS to confirm that components fulfill technical cleanliness specifications according to the VDA19 and ISO16232 standards. They can set up specific parameters such as particle size range, chemical classification rules, area of interest, and stop criteria and store these as a "recipe." The recipe can then initiate the sample testing with a few easy clicks—without any further monitoring until the analysis is completed. Users can run these recipes overnight or while they're performing other work, saving them substantial amounts of time. A report can be generated automatically according to automobile industry standards or to the user's specific requirements. When an analysis is complete, users can revisit particles of interest for further analysis.

To determine quality within steel production and steer the production process towards a higher level, dedicated automation software is available for automated analysis of steel inclusions and report the insightful ternary diagrams.




Report example according to ISO16232 standards, generated with the dedicated technical cleanliness automation software.

# Potential Barriers & Solutions

While automation presents clear advantages, sometimes barriers exist that prevent users from taking advantage of the enhanced efficiency it offers. Here are some of the common barriers and ways to overcome them.

### Writing automated scripts

One barrier is the need to write automated scripts—or the commands to be completed by the SEM without user intervention. While today's SEMs can be programmed to acquire and analyze consistently high-quality, the user must have experience with programming languages, such as Python. Python is relatively easy to implement, yet some organizations may not have the time or skills to devote to the effort.

For organizations that need help, Thermo Fisher Scientific offers Phenom Process Automation , which provides dedicated application engineers to develop user specific automated scripts. Whether you need to acquire images on specific areas of samples, find and select structures based contrast levels, or automatically generate analysis reports, Phenom Process Automation can design the best solution for your workflow, while providing a customized user interface that meets your specific requirements.

### Equipment failures

Another barrier is the potential for equipment failures during an automated workflow. Conventional tungsten sources can burn out after 100 hours, requiring weekly replacement for an SEM that's constantly in use. It also means automated workflows can fail midway through an unsupervised process, requiring extra time and money to repeat the workflow.

By choosing an SEM with a cerium hexaboride ($CeB_6$) electron source , operators can avoid this problem. Whereas a tungsten electron source eventually evaporates and breaks during imaging, sometimes contaminating other parts of the microscope, a $CeB_6$ filament has a predictable lifetime and can be replaced between operating sessions. In addition, the average $CeB_6$ electron source has a service life of at least 1,500 hours, requiring far less replacement. Software ensures that the source hours equal operational hours by hibernating the source when the SEM is not in use.

### Monopolization of the instrument

Finally, some busy facilities worry that automation will keep their SEM tied up and prevent other researchers from having access to the microscope. While it's important not to interrupt an automated workflow once it has begun, a key benefit of automation is the ability to run workflows overnight, on weekends, and at other times when no one is around. By setting up automated processes to be completed during low-use times, organizations can actually extend the use of their microscope, ensuring they reap the full value of their SEM investment.

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# Automate your manual, repetitive processes

Are you wasting time acquiring SEM images? Are data collection and analysis a struggle? While searching for that one defective particle is part of the job, doing so for hundreds of samples can be repetitive and time-consuming.

By automating routine processes, you can get fast, accurate results that improve efficiency and reduce the risk of human error.

Watch the automation webinar

Speak with an SEM expert

Find out more at **thermofisher.com/phenom-xl**

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