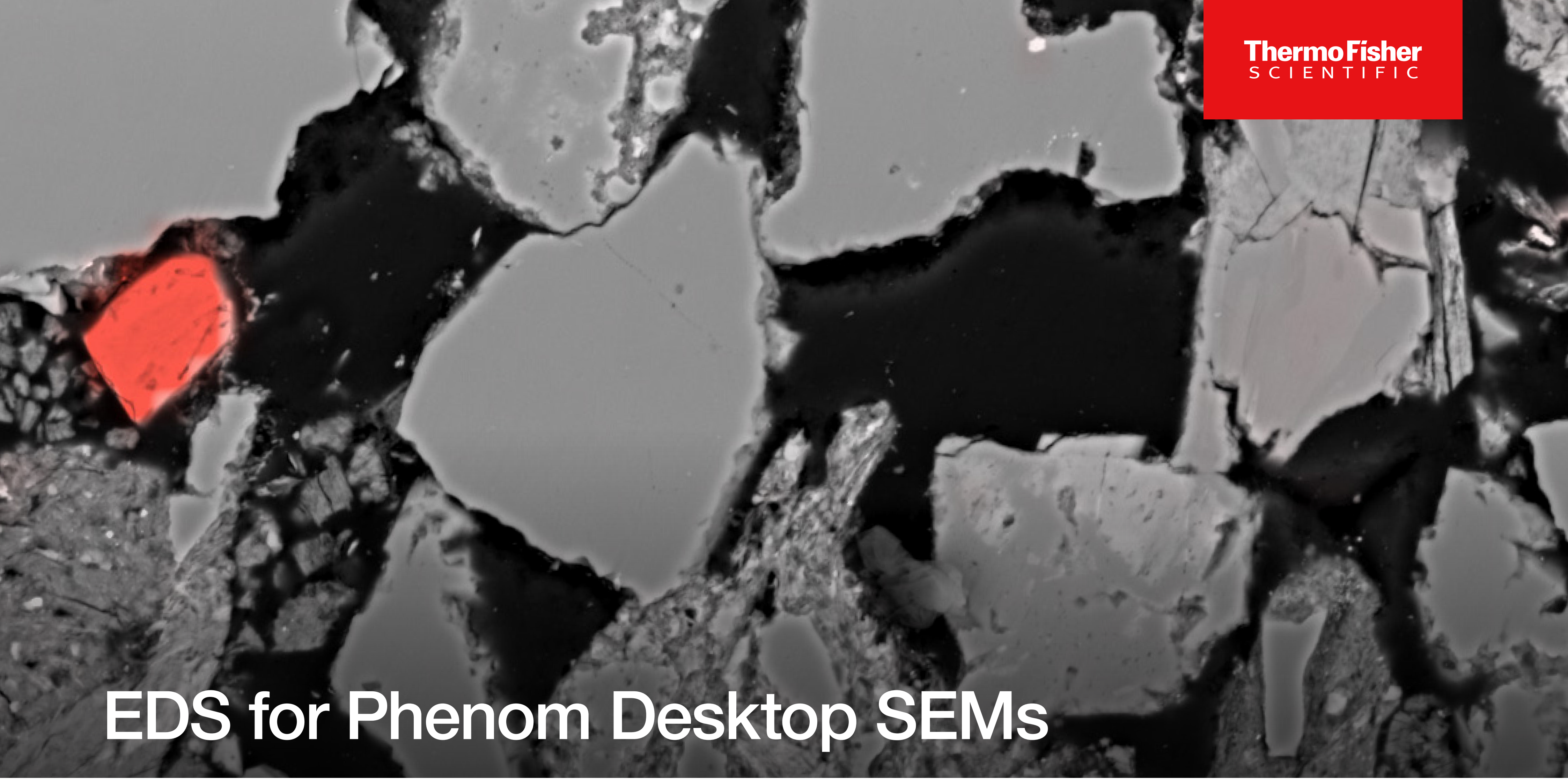


EDS for Phenom Desktop SEMs

The power behind intuitive imaging and EDS analysis

Thermo Scientific Phenom Desktop SEMs redefine speed, ease-of-use, and performance. The intuitive user interface enables all levels of users to easily obtain an SEM image. All Phenom Desktop SEMs support energy dispersive X-ray spectroscopy (EDS), complementing SEM imaging with comprehensive elemental analysis. Robust peak identification, reliable quantification, tailored application packages, and tight hardware integration support a full analytical workflow that can be reached with a few clicks.

Tackle your most pressing analytical challenges with Phenom Desktop SEMs.

Electron microscopy with a Phenom Desktop SEM

Thermo Scientific™ Phenom™ Desktop SEMs fill the gap between optical microscopy and floor-model SEM analysis, expanding the capabilities of research facilities in many ways.

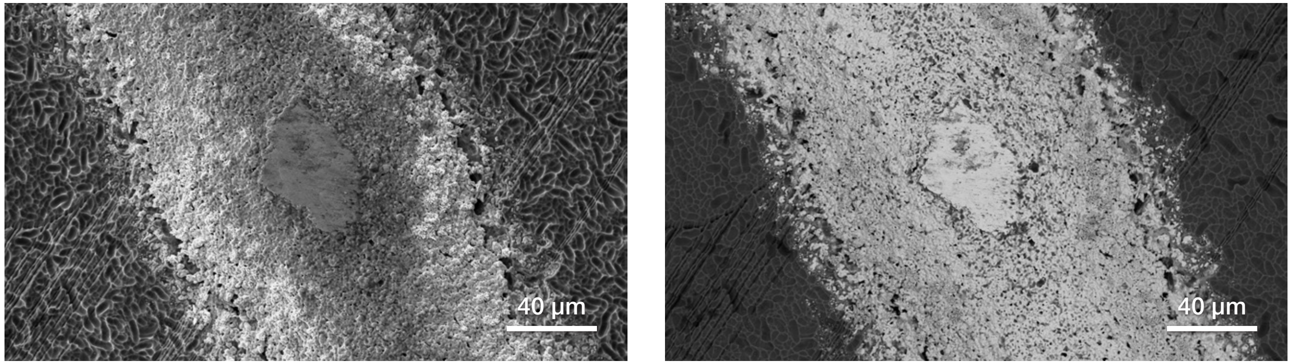


Figure 1. SED image (left) and BSD image (right) of a solar cell. The differences in observable information are clear: the BSD image provides elemental contrast, while the SED image shows topological information.

The high stability and small form factor of Phenom Desktop SEMs allow them to be used in practically any lab environment because they do not require specialized infrastructure or expert oversight. The instrument architecture and the sample loading mechanism ensure quick imaging with minimal time spent tuning between experiments. Their long-lifetime CeB_6 source offers high brightness while requiring low maintenance. They offer fast, high-resolution imaging via their four-segment backscattered electron detector (BSD) that yields sharp images and provides chemical contrast information. An optional secondary electron detector (SED) provides surface sensitive imaging, and an optional energy dispersive spectroscopy (EDS) detector provides elemental analysis.

Phenom Desktop SEMs provide the best high-resolution imaging results in their class. Most Phenom Instruments are equipped with EDS, underlining the added value for many applications.

Extending applications with EDS

Energy dispersive X-ray spectroscopy (EDS or EDX) provides information on the composition of materials by analyzing the characteristic X-rays that are generated by the interaction of the sample with the electron beam. The high brightness of our CeB_6 and FEG sources, in combination with our detector geometry, offers the advantage of a high count rate (number of detected X-ray events per second) without compromising on resolution.

EDS is a commonly used technique in electron microscopy because it is fast, accurate, non-destructive, and provides local information in a microvolume. These aspects are highly attractive in many fields, such as filtration, construction, surface analysis, and mineralogy.

Phenom ParticleX Desktop SEM

A growing number of manufacturing companies are establishing scanning electron microscopy (SEM) systems in-house. This trend from outsourcing to in-house analysis is growing, and the benefits, such as the ability to perform a broad range of automated desktop analyses, chemical classification, and verification according to specific norms, are clear. Timely and accurate quality control are prerequisites for today's manufacturing. The Thermo Scientific™ Phenom™ ParticleX™ Desktop SEM is a versatile solution for high-quality, in-house analysis. It provides the ability to carry out fast analysis, verification, and classification of materials, supporting your production with fast, accurate, and trusted data. The system is automated and offers multiple sample analysis, making testing and classification faster.

Typical examples of automated analysis of multiple samples are to monitor critical characteristics of metal powders, identify particle size distribution, detect foreign particles, and individual particle morphology. From a crime scene, forensic samples must be checked for the presence of gunshot residue (GSR), and the results should be unambiguous. In these examples, the number of samples cannot be a limiting factor, and so a fast and reliable method is needed. For automated EDS analysis, please also see the Phenom ParticleX Desktop SEM.

Analytical data in just a few clicks

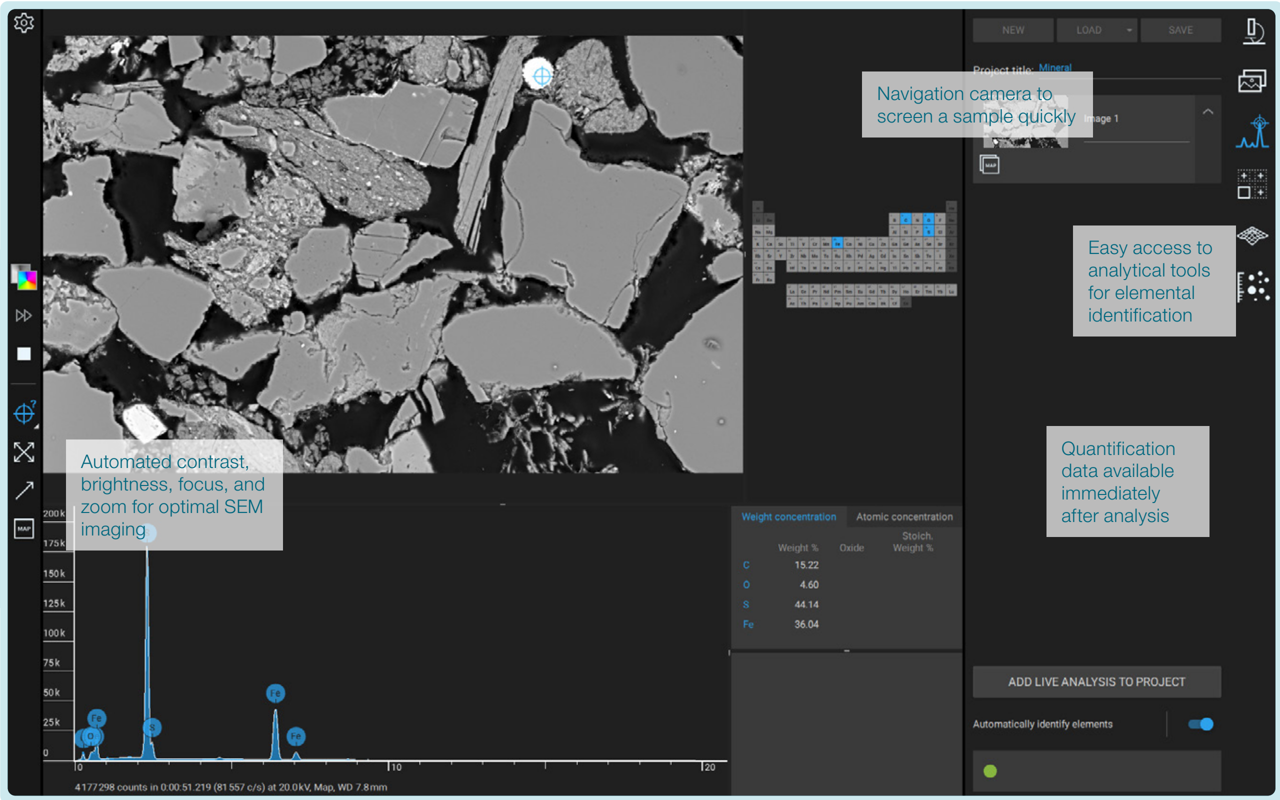


Figure 2. EDS capabilities embedded in the heart of the SEM UI. You can switch between analytics and imaging with a single click.

For a Phenom Desktop SEM, the detection of particles of several micrometers is extremely easy, as is the analytical analysis on the area of interest.

Add analytical data to your image with as little effort as it took to acquire the SEM image.

Within the main SEM imaging UI, you can immediately switch to chemical analysis by selecting the EDS icon. The live survey gives direct access to a local measurement by switching the cursor to a crosshair that can be used to initiate a spot analysis on the SEM image.

The UI simultaneously highlights identified elements on the periodic table and shows details of the spectrum. Less than two minutes after loading a sample, it delivers insights into both particle morphology and composition.

Unbiased analysis

The iterative routine compares simulations with data directly, leading to the highest accuracy very quickly.

SEM-EDS is a widely adopted and mature technology. It requires reliable processing algorithms in order to transform an acquired spectrum into meaningful, accurate, and consistent information. Although we cannot make EDS simple, we can make it easy to use by automating the workflow for almost all applications. This reduces both the training time and operator dependency. Our approach is based on holistic spectrum deconvolution, which means that it uses all data present in the spectrum and automatically corrects for all relevant factors that influence the result.

The data can be automatically exported as EMSA files (text files that contain spectral data with header info) or be collected directly in a report. Furthermore, the Phenom Desktop SEM project files are compatible with open source software, such as Hyperspy, for full flexibility in data processing.

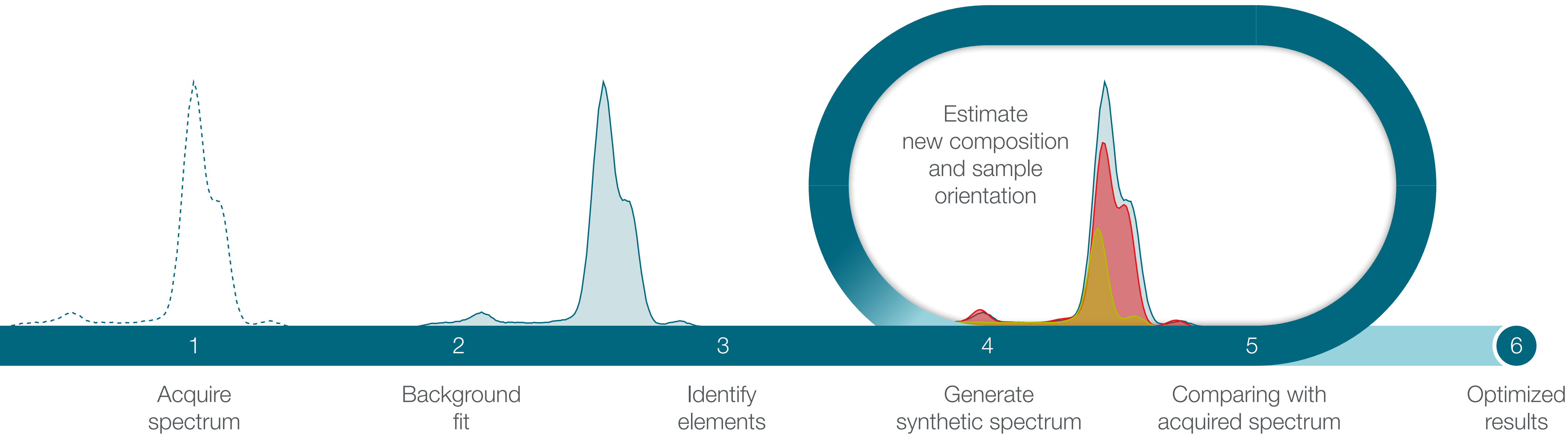


Figure 3. The automated workflow for EDS analysis eliminates sample-specific settings.

Full integration of hardware and software

The EDS detector is fully integrated in the microscope, meaning that both the hardware and software are fully aligned. The detector settings are automatically optimized for the chosen electron beam configuration so that no accidental misalignments can occur.

Differences in measured compositions may sometimes occur due to changes in the acceleration voltage in the electron column. The Desktop SEM's EDS software allows all accelerating voltages and automatically performs the required corrections.

Phenom Desktop SEMs are installed and maintained via service and application engineers who are familiar with the complete system and can support you in your local language, so we do not depend on modular experts. Thermo Fisher Scientific continues to innovate to take maximum advantage of this unique integration by making software updates regularly available at no additional cost.

Additionally, because both the system and detector are Thermo Scientific instruments, you can be assured of seamless installation and comprehensive product updates.

EDS specifications	Niminci
Detector type	Silicon drift detector (SDD)
Detector active area	25 mm^2 (optional* 70 mm^2)
X-ray window	Ultra-thin silicon nitride (SiNx) window, allowing detection of elements B to Cf
Energy resolution	Mn Kα ≤132 eV
Processing capabilities	Multi-channel analyzer with 2,048 channels at 10 eV/Ch
Max. input count rate	300,000 cps
Hardware integration	Fully embedded, no external digital beam control needed
Software	• Integrated in Phenom Desktop SEM user interface • Integrated column and stage control • Auto-peak ID • Iterative strip peak deconvolution • Export functions: CSV, JPG, TIFF, ELID, EMSA • Report: ODT format

Table 1. Hardware and software for analytics in a Phenom Desktop SEM are fully integrated.
***Optional for ParticleX Systems. Please contact your local sales manager for further information.**

The full integration of the EDS detector results in a reliable automated workflow so that no complex choices need to be made for the best results.

Combine speed with quantification

When an analysis needs to be quantitative, both the identities of the elements and their concentrations need to be calculated from the EDS signal. The Phenom Desktop SEM's EDS software is designed to do this all automatically, and there is no need to adjust settings when changing samples. The software also corrects for inherent artifacts present in any EDS detector, which is one of the advantages of our proprietary EDS solution.

In the example of galena, a PbS mineral, the signals of both elements partially overlap. The Phenom Desktop SEM's algorithm is capable of distinguishing both signals anywhere on the mineral's surface and correctly quantifying the composition.

Where a spot analysis is deemed useful, such as the analysis of specific phases or grain boundaries in metallurgical samples, an overview over a line, or even an area, is sometimes desired. A line scan may be of interest to identify variations in element concentration along features such as a cross section. The scan performs a full quantification over the line selection and uses colored profiles to display the distribution of specific elements. See Figure 5 for an example of brighter areas of silver over a solar cell surface.

> The automated solution leads to a fast time to result, even for the most challenging samples under the most challenging circumstances.

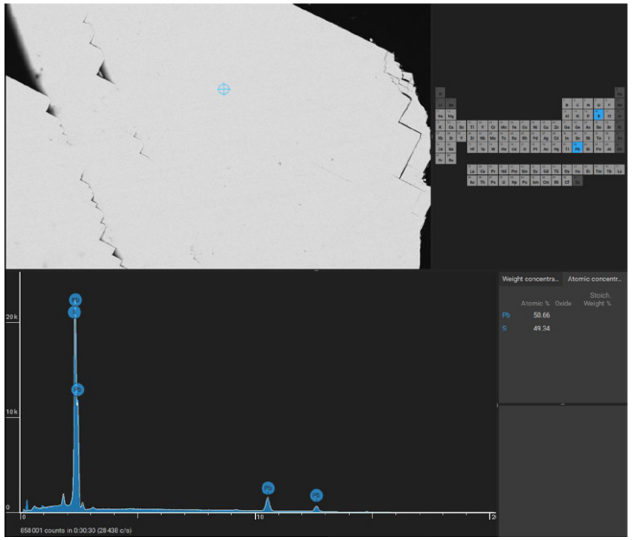


Figure 4. EDS analysis of galena (PbS) must deal with the Pb peak (Mα = 2.346 keV) that is very similar to the S peak (Kα = 2.307 keV), resulting in an overlap in the spectrum. The algorithm automatically deconvolutes the peaks and determines which element contributes to what extent to the overall spectrum.

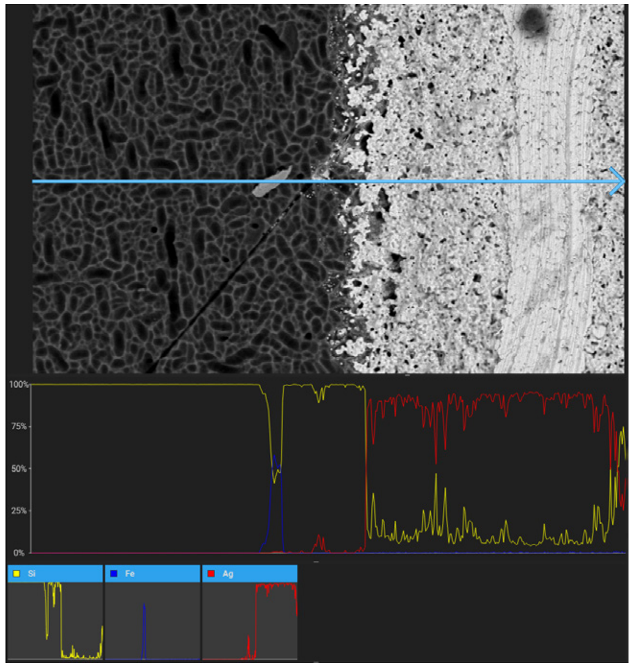


Figure 5. Line scan over a solar panel immediately identifies potential contamination (Fe) along the interface between Ag and Si.

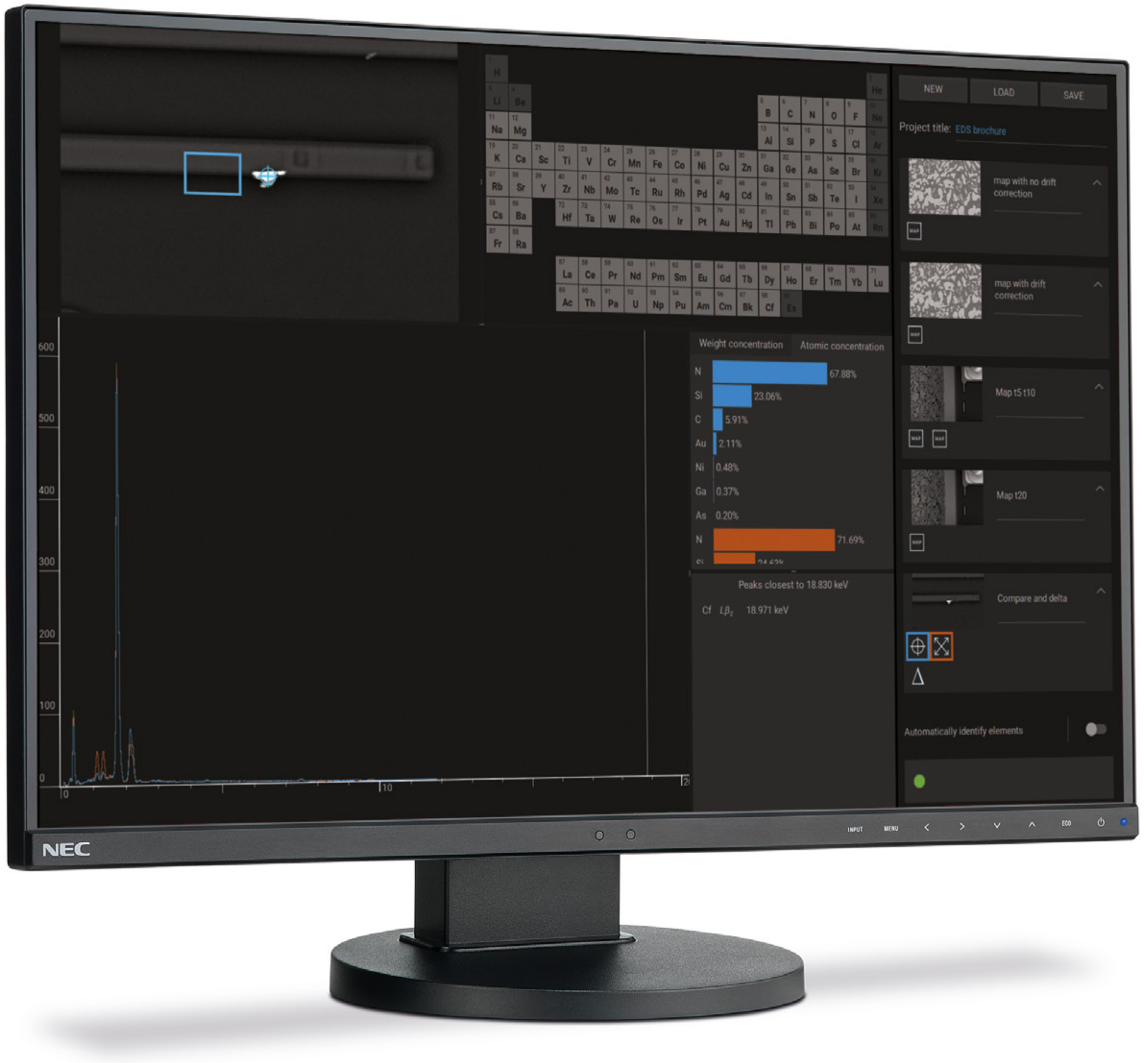


Figure 6. A very small particle can be identified as contamination by subtracting the sample background (blue square) from the point measurement in the middle of the particle. This shows that the particle has a clearly different composition than may be expected from the rest of the sample.

Detect the smallest amount of contamination

In typical quality control work, the particles suspected to be contamination are approximately the same size as the electron beam interaction volume. In such cases, it helps to acquire a spectrum of the background near the suspected particle to analyze. Alternatively, the background spectrum can be subtracted from the particle spectrum to obtain more precise information on which signal is generated by the particle itself. This allows you to identify a small organic feature as contamination on a bonding pad of a microelectronics chip, as indicated in Figure 6.

Even very small contamination particles can be detected by simply comparing and subtracting several spectra.

Fastest time to results, even on larger areas

X-ray analytical mapping can help you understand how a sample's composition varies over the entire surface. The first results are visible within a few seconds, and gradually improve over time, as shown for a microelectronic circuit in Figure 7.

Accurate results can also be achieved under even the most demanding imaging conditions, like when the sample drifts. This is corrected for by our automated drift correction mode, so that both elements can clearly be distinguished even on a large area, as shown in Figure 8.

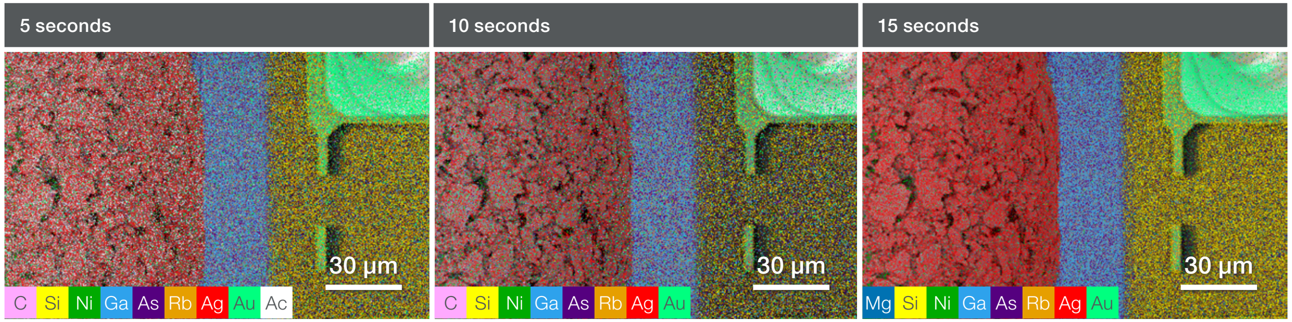


Figure 7. X-ray analytical mapping shows the first results within seconds and then builds up the elemental identification over time, as shown by the screenshots taken after 5 seconds (left), 10 seconds (middle), and 15 seconds (right).

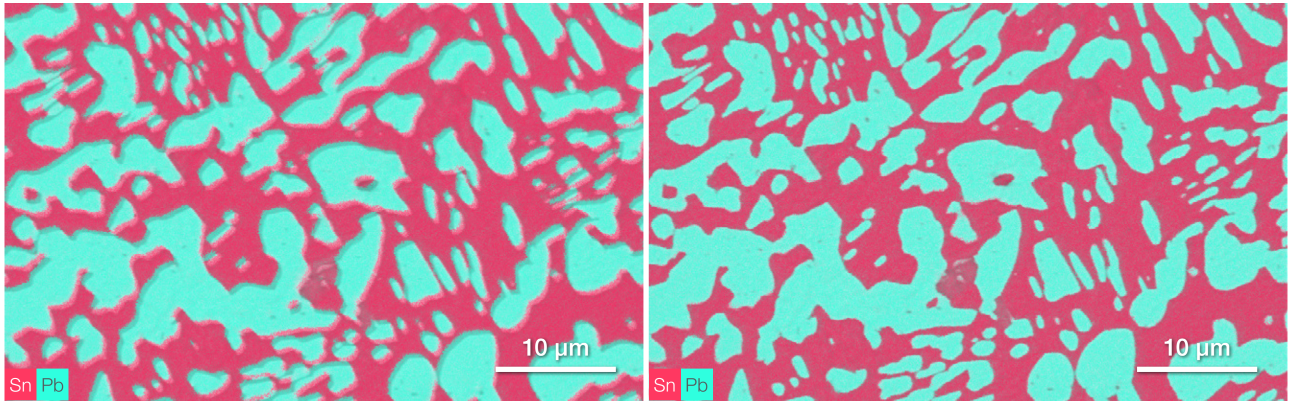


Figure 8. A PbSn solder imaged in maps mode, without (left) and with (right) drift correction enabled. On the right, the edges are much sharper.

Within a few seconds, the results are displayed, proving to be indicative for immediate interpretation.

Phase mapping

When analyzing complex multiphase materials, it becomes challenging to display all the combinations of colors in a way that is easy to interpret.

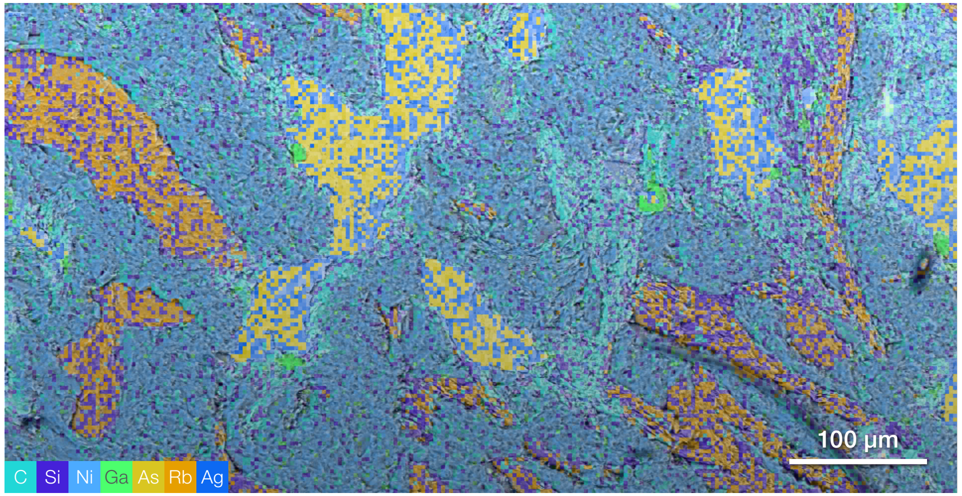


Figure 9. EDS mapping results of a mineral. Visualizing the elemental distribution of a multiphase mineral is challenging due to ambiguity when interpreting various color combinations.

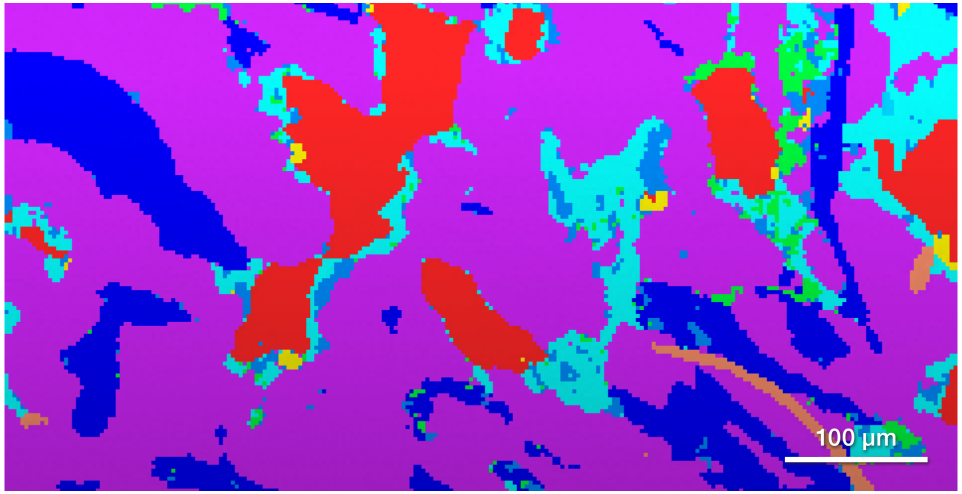


Figure 10. Phase mapping greatly simplifies the dataset, making it easier to interpret the results.

For example, Figure 9 shows an EDS mapping analysis of a multiphase material, in this case a mineral. Some of the areas are distinctly rich in sulfur or potassium, but across the majority of the sample it is difficult to pinpoint the localization of each element because many elements occur across the entire sample.

When multiple colors are overlaid, the resulting picture becomes challenging to interpret: some areas area clearly blue, whereas others are more yellow with a tinge of blue.

The solution to this problem is calculating material phases that are present in the material. This is done with a technique called principal component analysis, which simplifies an analytical dataset and emphasizes potentially hidden trends. The maps based on EDS analysis contain spectral data for each pixel. When calculating the chemical phases, the pixels are grouped based on the similarity of this spectral data. As a result, pixels with similar spectra will be combined into the same phase, regardless of the quantification results.

The result (Figure 10) is easier to interpret as each phase is shown in a unique color. When looking at the mineral, it is now evident that the specimen contains four major phases along with five minor ones.

ChemiSEM Technology on Phenom Desktop SEM

EDS mapping typically yields a static result: the operator investigates a specimen, finds a feature of interest, and analyzes the entire area.

The latest advances in EDS mapping now allow you to perform the analysis live. At the press of a button, the SEM image is colorized based on elemental composition (Figure 11).

Thermo Scientific™ ChemiSEM™ Technology allows you to navigate the specimen while a color overlay highlights elemental differences that might be less obvious from the SEM image alone.

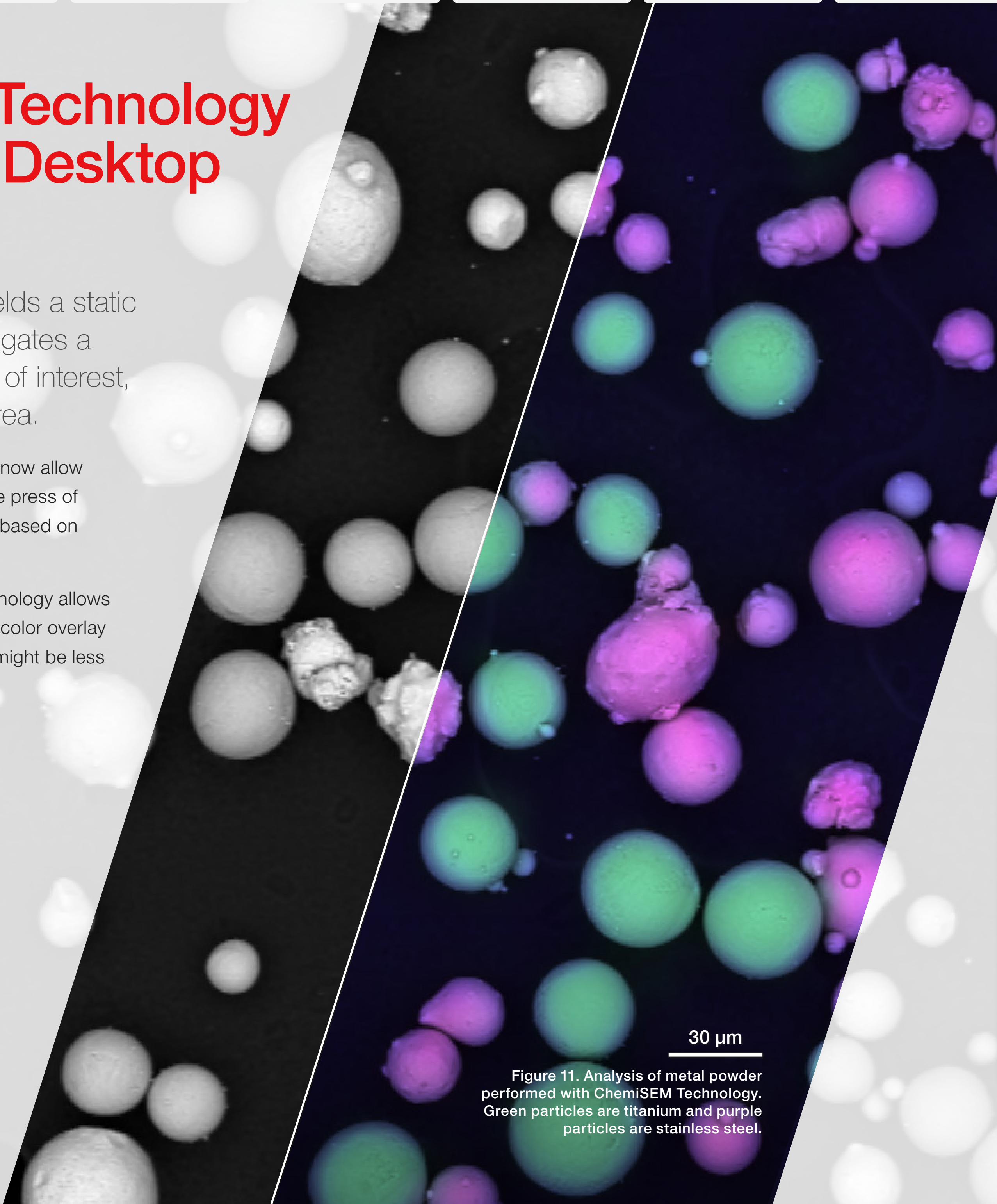
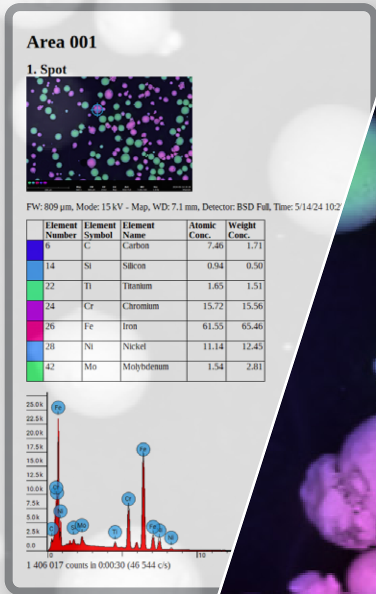


Figure 11. Analysis of metal powder performed with ChemiSEM Technology. Green particles are titanium and purple particles are stainless steel.

Lastly, the EDS software plugin makes it possible to perform a subsequent analysis. When saving the data, a report is generated automatically (Figure 12).



Area 001

1. Spot

FW: 809 µm, Mode: 15 kV - Map, WD: 7.1 mm, Detector: BSD Full, Time: 5/14/24 10:2

	Element Number	Element Symbol	Element Name	Atomic Conc.	Weight Conc.
	6	C	Carbon	7.46	1.71
	14	Si	Silicon	0.94	0.50
	22	Ti	Titanium	1.65	1.51
	24	Cr	Chromium	15.72	15.56
	26	Fe	Iron	61.55	65.46
	28	Ni	Nickel	11.14	12.45
	42	Mo	Molybdenum	1.54	2.81

1 406 017 counts in 0:00:30 (46 544 c/s)

Figure 12. Automatically generated report.

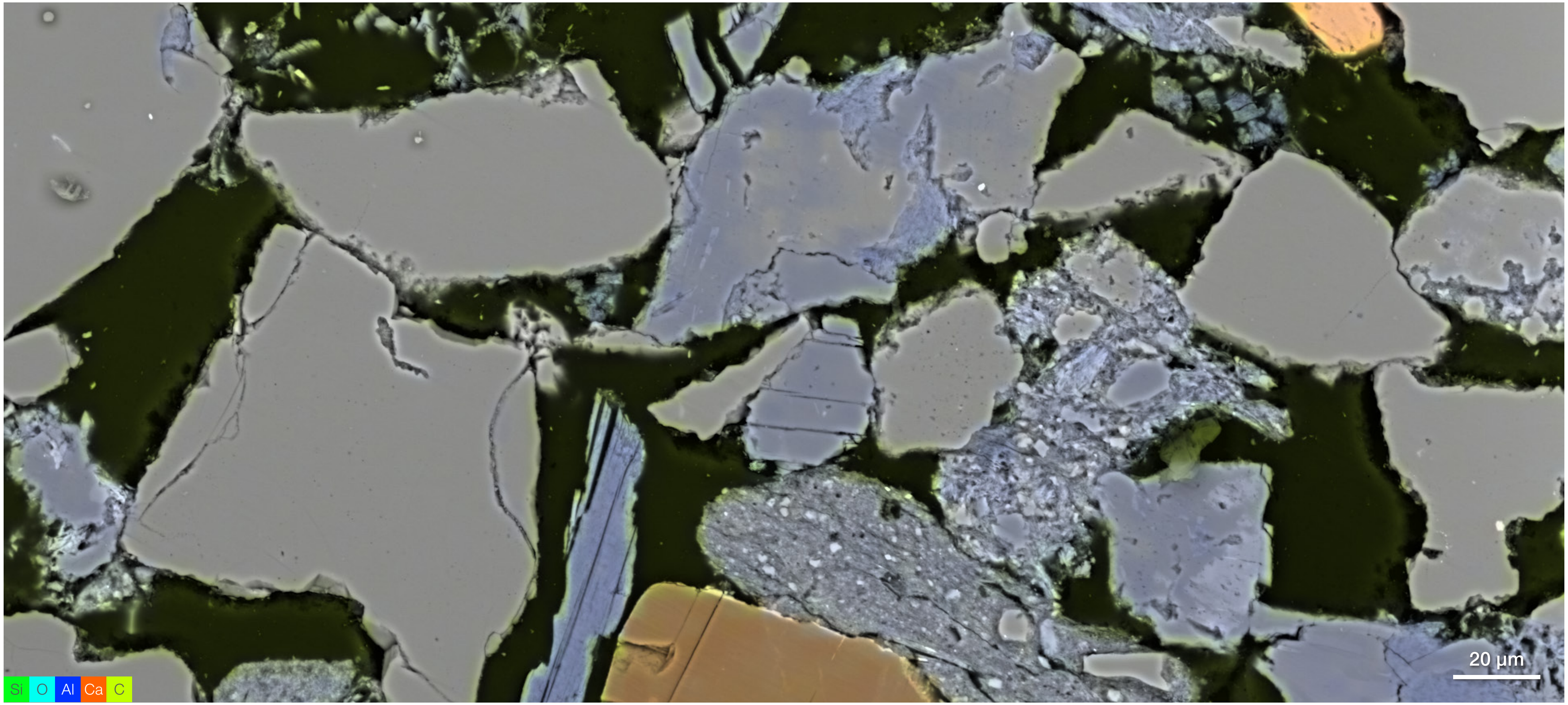


Figure 13. ChemiSEM analysis of a mineral.

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