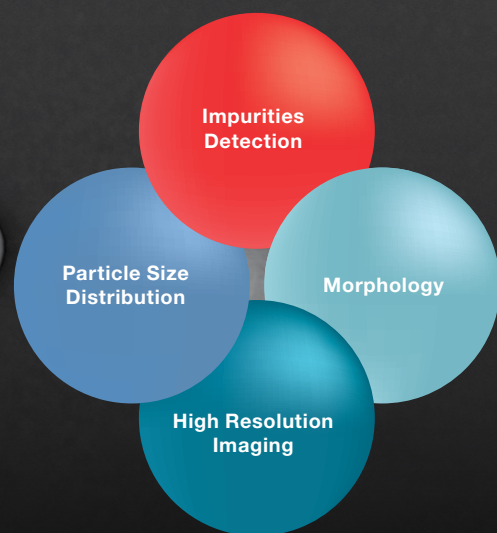


Explorer 4 Additive



Qualify & Quantify your Metal Powders
for Additive Manufacturing

Quick & Easy Analysis of Size, Shape & Chemistry
Using Automated SEM with EDX Spectrometry

We understand your challenges

In additive manufacturing, powder size, shape and chemistry can have a significant impact on the powder bed formation, melt pools and microscopic homogeneity.

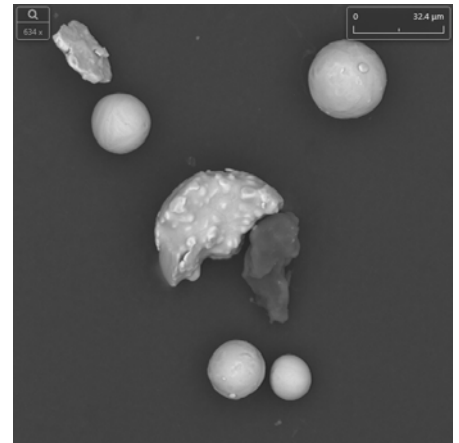
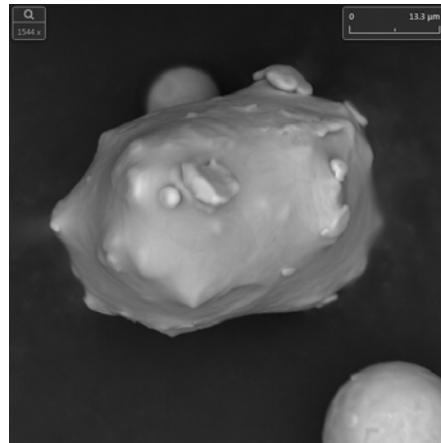
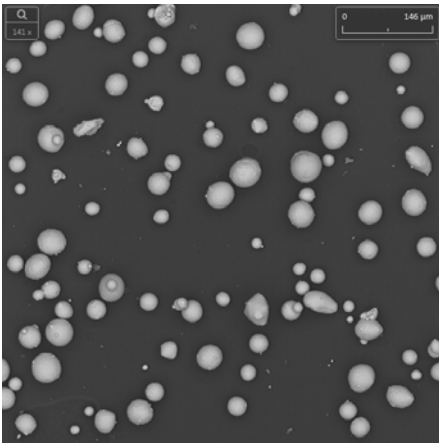
Excessive variations and unknown properties can lead to nonuniform layering, increased defects, poor surface finish and potentially catastrophic failures. With a clear understanding of the powder

characteristics, users can proceed confidently from the initial build through repeated recycling, knowing their powder is consistent in size and shape and without fear of contamination.



The Importance of Metal Powder Quality Control in Additive Manufacturing

The Explorer 4 Additive automatically and simultaneously analyzes three of the most critical characteristics of powders used in powder-bed and powder-fed Additive Manufacturing processes.



- Particle Size Distribution

- Wide measuring range, from submicron to millimeter particles
- Reliably represents non-spherical particles as well as multi-modal and skewed distributions
- Requires no material properties input (e.g. refractive indices)
- Capable of reporting number distribution or volume distribution

- Morphology

- Particle shape analysis to identify agglomerates, broken particles & satellites
- Built-in recipes can find “deformed” particles based on pre-determined criteria, or the user can set their own pass-fail criteria based on the parameters of their choice.
- Automated processes remove user subjectivity and ensure consistency across batches

- Foreign Particle Detection

- Fully integrated EDX spectrometry for the detection and identification of a few foreign particles amongst thousands
- Particle Inspector software allows for the creation of detailed reports on particles of interest
- Post processing and data mining without the need for re-analysis

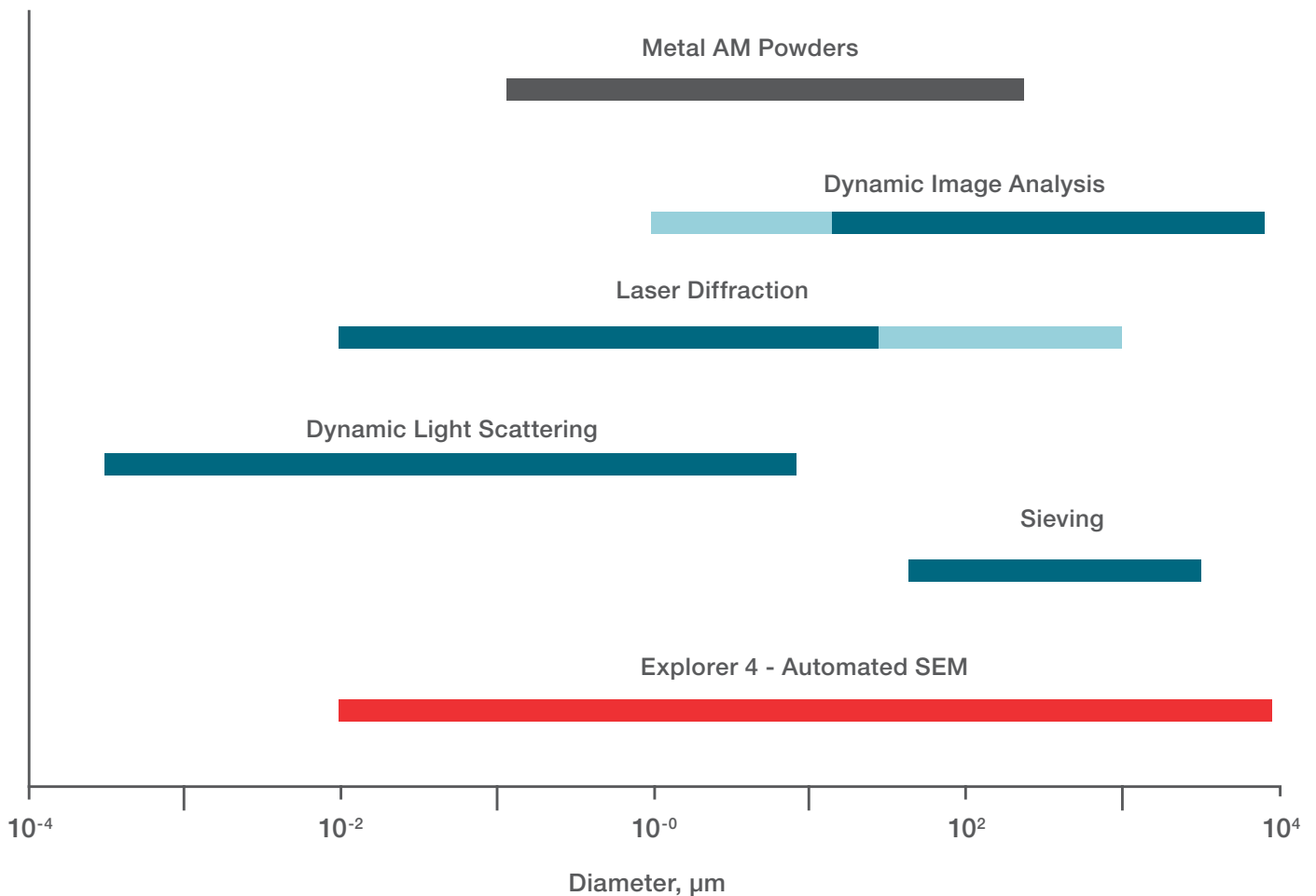
Particle Size Distribution

Scanning Electron Microscopy (SEM) is the only technique that accurately and precisely measures the *entire* range of powders used in Additive Manufacturing.

While laser diffraction measures spherical particles in the smaller particle size range (as used in DMLS and SLM printers), it can mis-characterize the larger particles used in EBM machines. The opposite can be true for Dynamic Image Analysis. Only the Thermo Scientific™ Explorer 4™ Additive SEM captures the complete range of powder sizes used in metal additive manufacturing, from 200nm to several millimeters.

Because the Explorer 4 Additive measures the maximum and minimum diameters, perimeter, and shape of each and every particle, there will be no errors due to incorrect assumptions of sphericity. Additionally, since the physical dimensions of the particles are measured directly, there is no need to enter the refractive indices of the material. The user can then

confidently measure the sizes of mixed or new materials without this additional concern. And, you can be confident that the characterization of potentially non-spherical recycled powders will be just as accurate the characterization of spherical virgin powders.

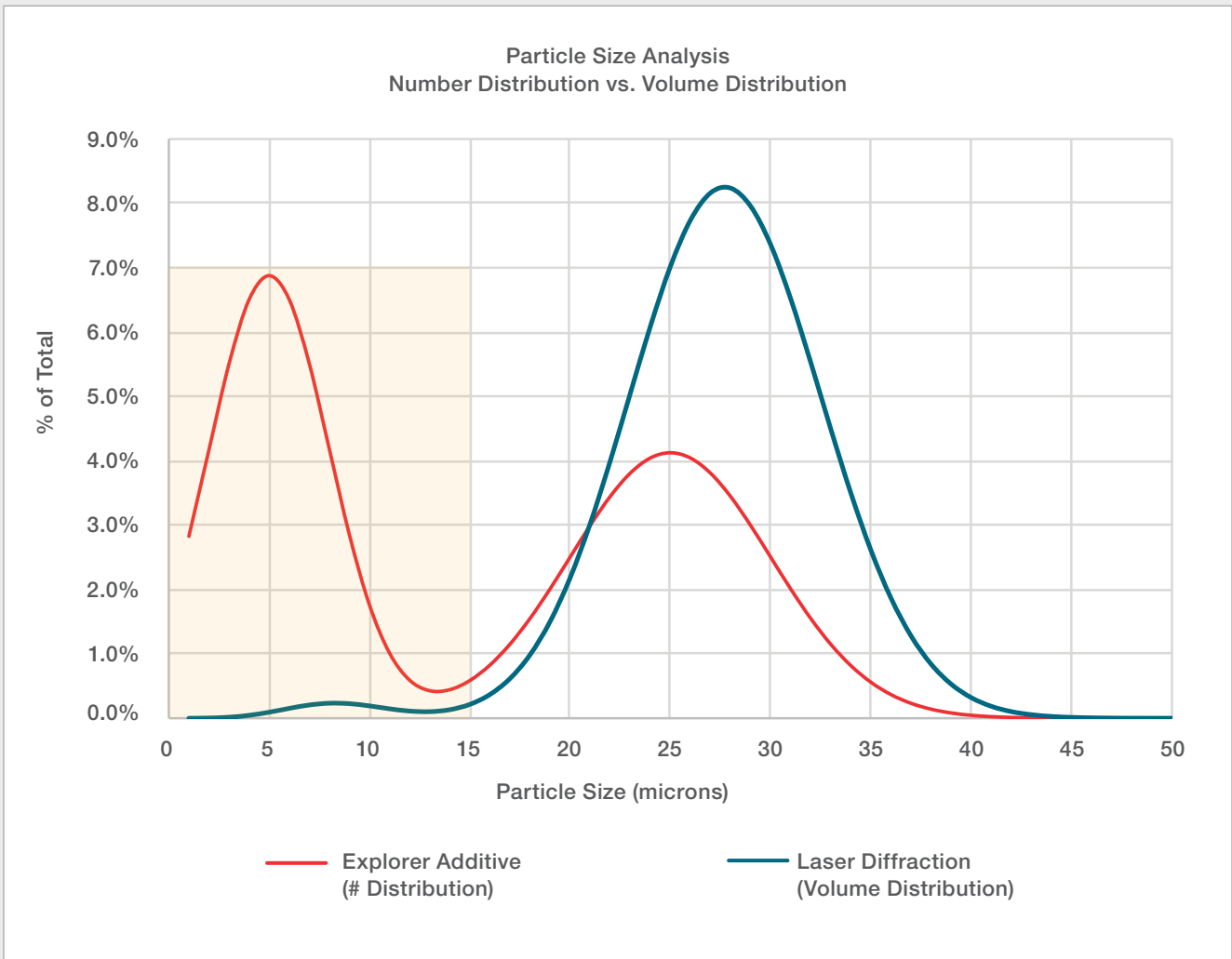


Did you know?

Laser Diffraction represents the particle size distribution as a function of the *volume* of the particles rather than the number of particles. This gives higher weighting to the larger particles in the histogram while minimizing the presence of the fines.

The chart below shows the analysis of the same powder using the two different techniques. As can be seen in the highlighted region, the number of smaller particles is quite significant (seen in the # Distribution), while their volume contribution is quite low (seen in the Volume Distribution).

Although the Explorer 4 Additive defaults to a number distribution, the user has the option of converting this to a volume distribution.



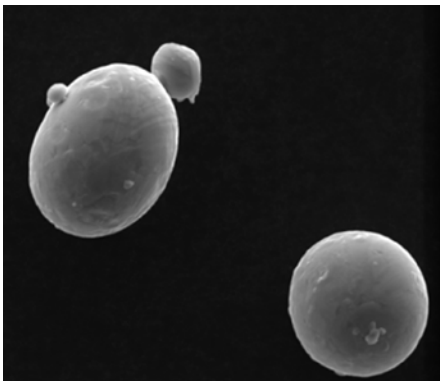
Morphology

The shape of the particles can greatly affect the flowability and packing density of the powder.

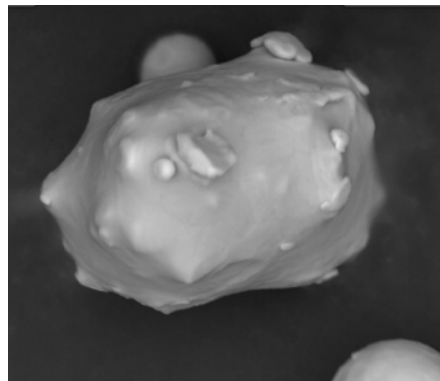
The Explorer 4 Additive automatically and simultaneously measures various size and shape parameters, such as minimum and maximum diameter, perimeter, aspect ratio, roundness, and feret diameter. All of which can be displayed as a histogram with 10%, 50% and 90% values (e.g. d10, d50 and d90).

For production environments, built-in recipes will find “deformed” particles based on pre-determined criteria, or the user can set their own pass-fail criteria based on the parameters of their choice.

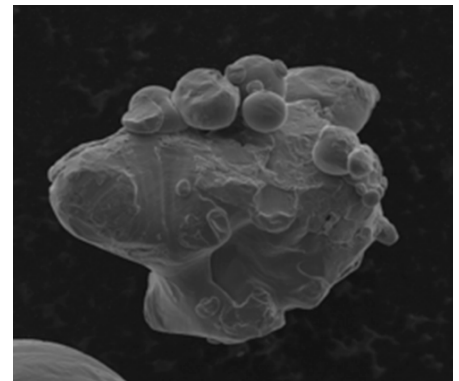
This automated process replaces user subjectivity with a quantitative and repeatable approach, assuring consistency across batches.



Bad Aspect Ratio, Good Roundness



Good Aspect Ratio, Bad Roundness



Deformed Particle (Bad Aspect Ratio, Bad Roundness)

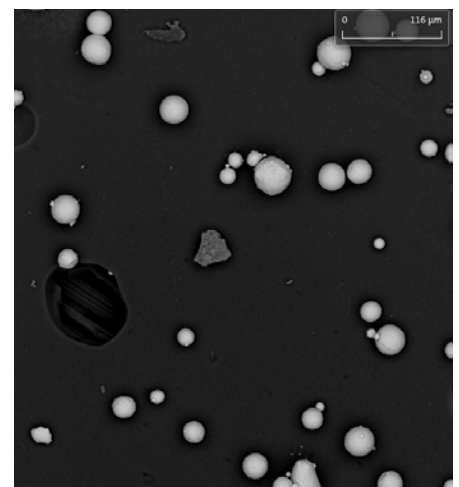
Impurities Detection

Fully Integrated & Automated SEM/EDX

Historically, scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDX) has been key to providing details on undesired particles. However, until now, this has been a time consuming and manual process.

Using customer feedback from the additive manufacturing industry, Thermo Fisher has developed the Explorer 4 Additive to automatically identify impurities, obtain their basic characteristics, and log their location. Utilizing the integrated Particle Inspector

software, users can automatically relocate particles of interest and create reports containing individual particle images, parameters and composition. This powerful program also provides an offline tabulated view of every particle, freeing up the instrument for continued testing.



Fe particle amongst Ti64 particles

Dual Purpose Applications

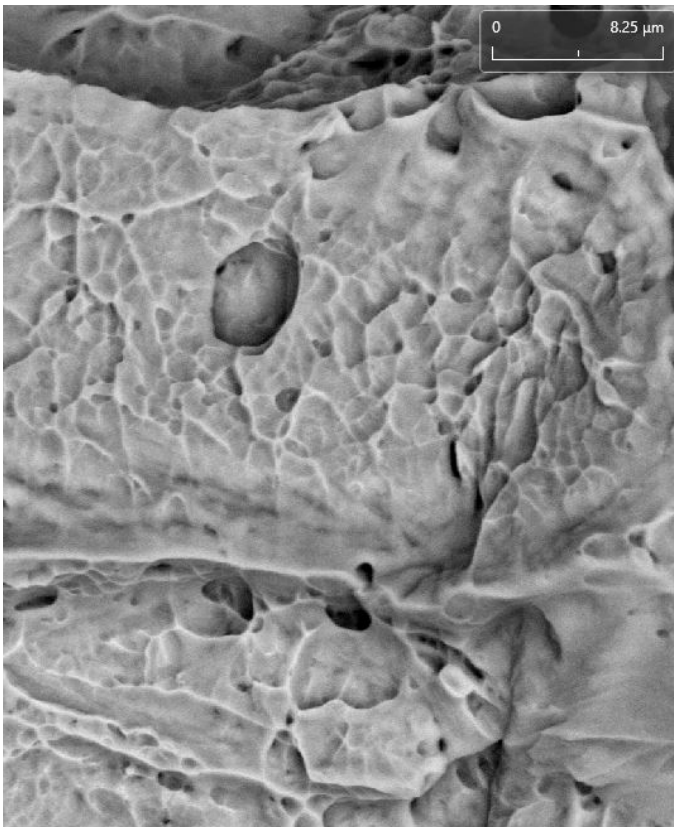
The Explorer 4 Additive can offer a dual purpose application of either an imaging system or a particle identification system.

Equipped with both a SED and quad BSED, the instrument can function as a traditional SEM and provide high magnification imaging for identifying critical surface features of coatings and grain structures or serve to collect size, shape and chemical composition for thousands of particles.

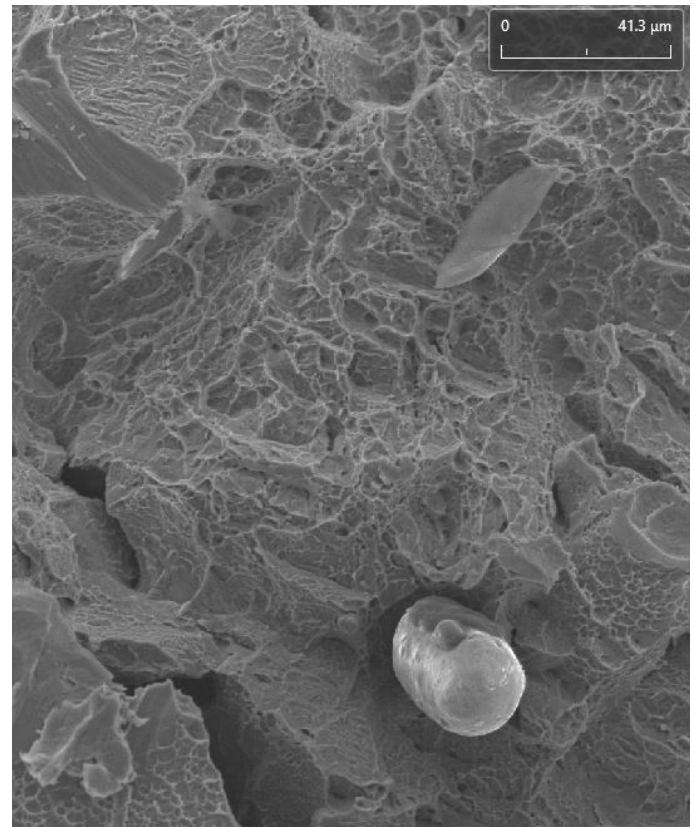
Using the instrument in Automated Feature Analysis (AFA) mode the user can classify huge data sets of particles or inclusions in minutes which can then be used to improve process control.

The Explorer 4 Additive is a fast and reliable platform for identifying and imaging:

- Cracks
- Inclusions
- Pores
- Particles
- Grain structures
- Fracture Surfaces



Ti64 fracture surface, imaged using SE detector



Ti64 fracture surface, imaged using Quad BSE detector

Explorer 4 Additive



Truly Integrated SEM/EDX Platform

- Fast analysis
- Vibration Isolation/ Electromagnetic Shielding
- Easy-to-use User Interface
- High up-time
- Plug-and-play design
- 1-click Reporting

Integrated vacuum pump

Integrated Uninterruptable Power Supply (100 – 240 VAC)

Optional integrated vibration isolation table

The powder size, shape and chemistry play key roles for beam-induced melting processes. While established technologies exist to characterize the size and shape of the particles, they do not detect and analyze foreign particles. The Explorer 4 Additive does all of these things, along with nanoscale resolution imaging capabilities. Using customer feedback from the Additive Manufacturing industry, The Thermo Scientific™ Explorer 4 Analyzer Additive has been built with these characterization challenges in mind.

- Direct Imaging with a Scanning Electron Microscope (SEM) is the best way to quantify particle size and shape. The morphology is unambiguously defined, and not influenced by multimodal or skewed size distributions.

- The Explorer 4 Analyzer is an Automated SEM with integrated EDX, developed to work in an industrial environment. Standard reports are generated; showing size and shape distributions and the identification of unexpected contaminant particles. Typical measurement times are 5 minutes per 1000 particles. Trace amounts of powders from previous printing cycles are readily identified.
- The Explorer 4 Additive has 14nm image resolution, allowing high resolution imaging of fracture surfaces, individual particles and surface imperfections such as pores, inclusions and microcracks.

- The Explorer 4 Additive analyzes powders automatically, allowing continuous and unattended operation. Operators can utilize the pre-defined recipes specifically designed for additive manufacturing, or more experienced microscopists can modify the recipes or manually operate the analyzer to specifically meet their requirements.
- Each particle is analyzed individually with corresponding data stored. Utilizing **Particle Inspector**, individual particles can be easily revisited for more in-depth analysis or imaging.

Specifications



Automated analysis

- Up to 10,000 particles/hr with full morphology and chemistry characterization, or up to 30,000 particles/hr without EDS

Detector

- Quad BSED and optional SED

Magnification

- 80x – 40,000x

Accelerating voltage

- 5 to 20kV

Electron source

- Long lifetime, thermionic source

Vacuum system

- High vacuum for conductive samples and charge reduction modes for non-conductive samples

Vacuum pump

- Oil free and turbo molecular pump

Vibration isolation

- Built-in vibration damping

Image resolution

- 14nm

Evacuation time

- < 90 seconds to high vacuum

Maximum sample size XYZ stage

- 100mm × 100mm × 35mm or 3.94" × 3.94" × 1.4" (W×L×H) with removable sample drawer

Maximum sample weight

- 1 kg / 2lbs

Relocation repeatability

- ≤ 7 micron (X and Y)

Room temperature

- 59° to 86° F (15° to 30° C)

Humidity

- 20% to 80% (non-condensing)

Power source

- 110 - 230 VAC, 50/60 Hz, 6.5 A

PC & console control system

- Windows 10 Professional
- 2x 1 TB hard drive, 16GB RAM
- 24" monitor

User Interface

- Perception for integrated SEM/EDX

EDX performance

- 25 sq mm, 137 eV , 6,000 CPS/nA¹

EDX detection range

- B to Am

EDS file format

- TIFF, EMSA, TXT, and CSV

Digital file format

- TIFF

Image quality

- 64 × 64, 128 × 128, 256 × 256, 512 × 512, 1024 × 1024, or 2048 × 2048

Chemical analysis

- Point or area spectra acquisition

Sizing accuracy

- 0.5 micron or better²

Sizing precision

- 0.09 microns or better²

System footprint

- 780 mm × 954 mm × 1703 mm or 31" × 38" × 67" (W × L × H)

System weight

- 193 kg or 425 lbs

¹ Measured on Mn (Ka) peak at nominal working distance

² Performance Grading System standard test procedure

Specifications are subject to change.

Automated and Simultaneous Analysis of Particle Size Distribution, Morphology & Impurities of Metal Powders

- Particle Size Distribution – Widest range of all techniques
- Morphology – Multiple measurements to choose from
- Impurity Detection – Just one particle amongst thousands will be detected
- High-Resolution Imaging – 14nm Resolution

Support you can depend on

Product maintenance

Our comprehensive service offering is based on corrective and preventive maintenance that not only reduces downtime, but also helps you improve your process. We offer multiple levels of support agreements, with varying degrees of access and response, including:

- System calibration
- On-site repair
- Depot repair
- Preventive maintenance
- System commissioning

Some options feature complete cost predictability, with all travel, labor, spare parts, and consumables included.

Education and training

We offer multiple training options to help you increase productivity by optimizing the use of your instruments and expanding the skills of your operators. You can receive hands-on instruction in your plant or at one of our training facilities in the USA, Europe and Asia. Our range of courses covers:

- Basic operation
- Calibration
- Routine maintenance
- Troubleshooting
- Certification

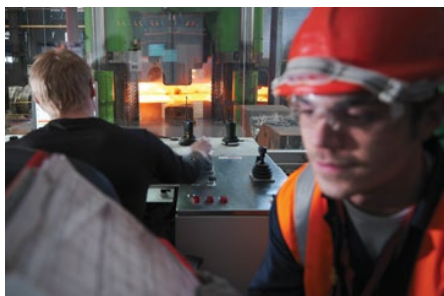
We will also work with you to develop a custom program that meets your specific training objectives, often incorporating your own operating procedures.

Professional services

Our certified engineers are available to review your process, perform benefit analysis and recommend improvements to help you meet your best-practice goals. We will develop an implementation plan that integrates all Thermo Scientific systems, as well as third-party components including:

- System layout and connectivity
- Software implementation
- Configuration and support
- Site modifications

You can rely on us to manage the entire installation and startup if you choose, including serving as a liaison with licensing agencies where necessary.



Parts and upgrades

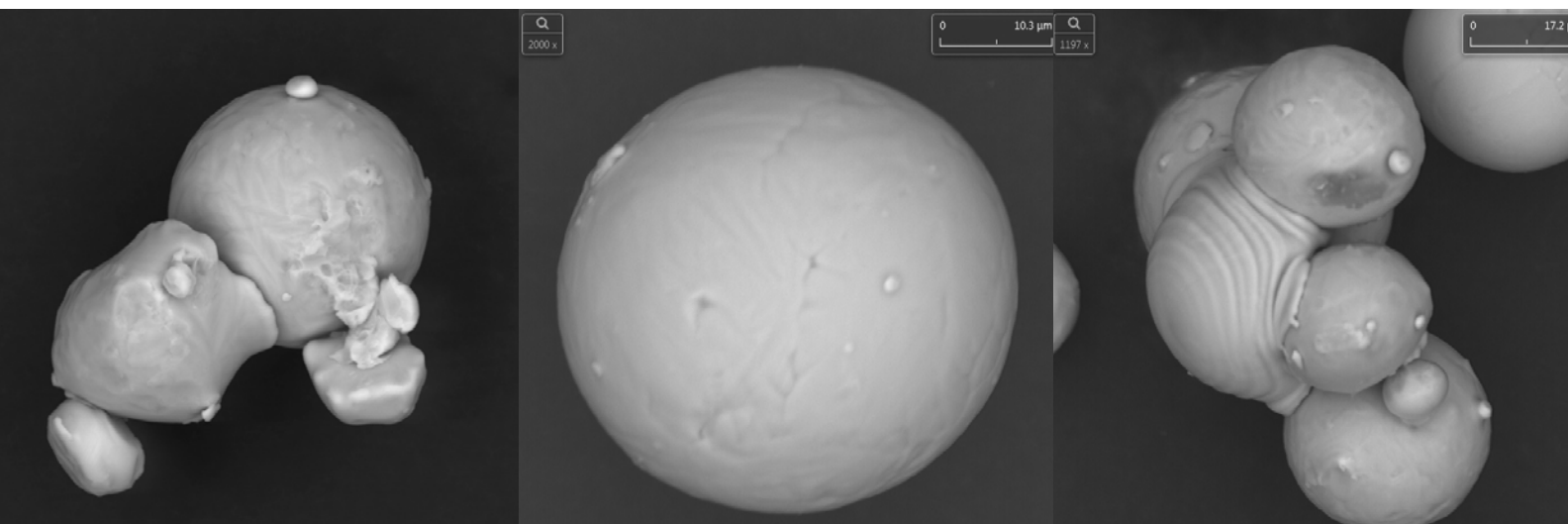
Our spare parts are designed specifically for your Thermo Scientific system, and we make it easy for you to secure high-quality, low-cost replacements by maintaining offices around the world that respond quickly to your phone or online requests. You can also extend the lifetime of your older instruments through our add-on system enhancement and retrofit packages, which adapt your instruments for new uses and eliminate the time and cost to retrain operators on new equipment.



thermofisher.com/EM-Sales

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Find out more at thermofisher.com/EM-Sales

ThermoFisher
SCIENTIFIC