BRUKER

M4 TORNADO

● High performance Micro-XRF spectrometer

Innovation with Integrity

Micro-XRF

M4 TORNADO – New Standards in Micro-XRF

Micro-XRF is the method of choice for highly sensitive and non-destructive elemental analysis of diverse samples, including inhomogeneous and irregularly shaped specimens.

The M4 TORNADO is a versatile instrument for fast and accurate high-resolution analysis of both small and large specimens. Samples require little or even no preparation at all for examination.

- Excellent spatial resolution using polycapillary X-ray optics for smallest spot sizes < 25 μm for Mo-K

- Flexible excitation through use of up to 2 X-ray tubes and 5 filters

- Ultra fast spectrum acquisition with XFlash® SDD technology
- Additional speed and information through an optional 2nd detector

- TurboSpeed X-Y-Z stage for distribution analysis "on the fly"
- Sample positioning supported by simultaneous display of 2 sample images in different magnifications

- Vacuum sample chamber for optimized light element performance
- EasyLoad function for fast and convenient sample exchange

- Reliable quantification of bulk material using a standardless FP model

Instrument Highlights

Efficient sample excitation

The use of polycapillary X-ray optics allows to generate high fluorescence intensities even on smallest sample areas. The X-ray optics allow to focus tube radiation from a large solid angle and concentrate it on spots < 25 µm for Mo-K radiation.

The optional use of two X-ray tubes permits very effective excitation of special groups of elements by choosing different target materials or by using one tube with a collimator.

Fast spectrum acquisition

The M4 TORNADO is equipped with our XFlash® silicon drift detector (SDD) technology. This ensures count rates of > 310 kcps (single detector setup) combined with an energy resolution < 145 eV. The 30 mm^2 active detector area allows to collect radiation from a large solid angle. An optional second detector speeds up data acquisition even more.

TurboSpeed stage

The large sample stage travels at a maximum speed of up to 100 mm/s. Combined with "on the fly" measurement, this ensures fastest possible mapping, as the detector is continuously collecting radiation.

Information on element distribution can already be obtained with an acquisition time < 1 ms per pixel. This allows a first overview of the sample composition within minutes. Additional frames can add details for refined analysis. Due to the high precision of the TurboSpeed stage, such multi-frame measurements can be carried out routinely. Longer acquisition times provide even more analytical details.

Convenience and ease of use

Convenience and easy handling are provided for the user through:
- The EasyLoad function for fast sample exchange
- The large sample chamber, enabling a stage travel of 200 x 160 x 120 mm
- Sample positioning supported by a fish eye camera and two optical video microscopes that show approx. 1 mm^2 and 10 mm^2
- Auto focus function for setting the sample height correctly
- Mosaic (tiled) images of high quality (stitching, shadow correction) for large area maps
- Distribution analysis with HyperMap, which collects complete data sets, supporting offline data evaluation.

Accurate and flexible quantification

Because samples are usually inhomogeneous, the M4 TORNADO uses standardless analysis based on fundamental parameter (FP) models. Based on such a FP model our software module M-Quant provides reliable results on the composition of bulk samples.

Fast mapping
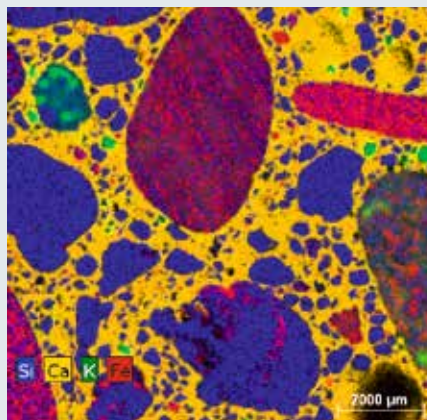
Fast mapping of a concrete sample (1 cm²) with 1 ms dwell time per pixel. Total measurement time: 3 min.

Applications

Cr Fe Cu Ca Pb Hg

Left – Backside of a painting by Max Klinger (1872, approx. 14,5 x 32 cm²) on a piece of wood (approx. 8 mm thick) covered with paper.
Right – A hidden painting is "uncovered" by multi-element distribution analysis: the distribution of Cr, Fe, Cu, Ca, Pb and Hg, contained in pigments used, produces a false-color representation of the picture.

Thin sections with high resolution

Screening of mineralogical samples. Image size: 166 x 140 mm², scan resolution: 3320 x 2800 pixels, step size: 50 μm, dwell time: 1 ms/pixel.

The M4 TORNADO is very versatile. Applications focus on material sciences, in particular on forensics, geology, RoHS measurements, archeometry, bioscience and many other applications are supported as well.

Forensics and archeometry

The M4 TORNADO is especially suitable for forensic analysis. This includes examination of layer systems like paint, extremely small material fragments and gunshot residue. It is also the ideal instrument for non-destructive analysis of documents and small works of art, e.g. for authentication.
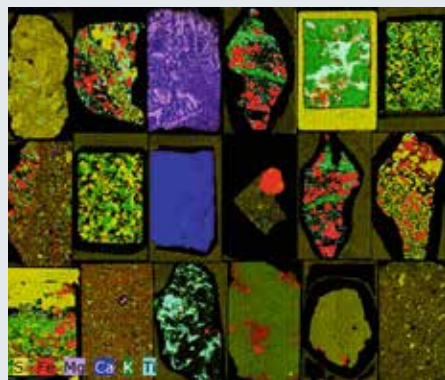
Geology

The large sample stage of the M4 TORNADO is predestined for the analysis of geological samples. Phase analyses or searches for trace elements can be performed easily to study geological processes such as rock formation or to assess ores for their mineral content. The M4 TORNADO software offers multiple options for analysis and data representation.

Restriction of the use of hazardous substances – RoHS

With the increased awareness of environmental and health hazards, detection of substances imposing such risks has become increasingly important. Analyses to determine compliance with the Restriction of the Use of Hazardous Substances regulation can be performed with the M4 TORNADO.

It can be used to determine heavy metal and other harmful element content – even if it is in the ppm range.
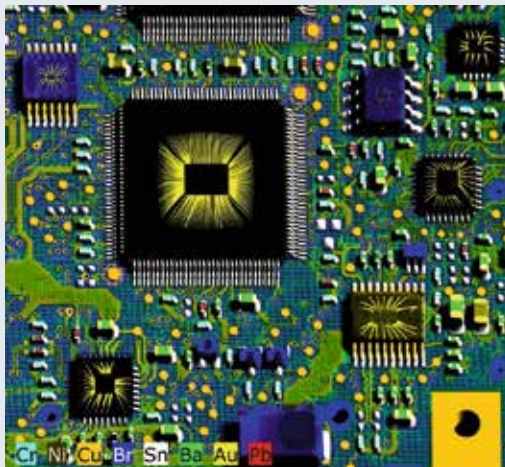
Image size:
44 x 40.6 mm², scan resolution:
2750 x 2538 pixels, step size: 16 µm, dwell time:
5 ms/pixel.
Left – Mosaic image of the analyzed PCB.
Right – Element distribution for hazardous elements (Br, Pb, Cr) and for Au (showing the bond wires of the integrated circuits).

Qualitative analysis of single points or examination of element distributions is possible for various sample types. These include electronic components, toys, consumer products and others. The high excitation efficiency of the M4 TORNADO allows fast screening and the detection of smallest traces.

Bioscience

The examination of the metabolism of biological samples can provide valuable information on environmental conditions, health or diseases.

Important indicators are the distribution of essential elements. Their distribution in plants and in animal organs can be examined with high spatial resolution and with high sensitivity using the M4 TORNADO. The fast data acquisition also permits screening of sensitive samples without causing any damage.
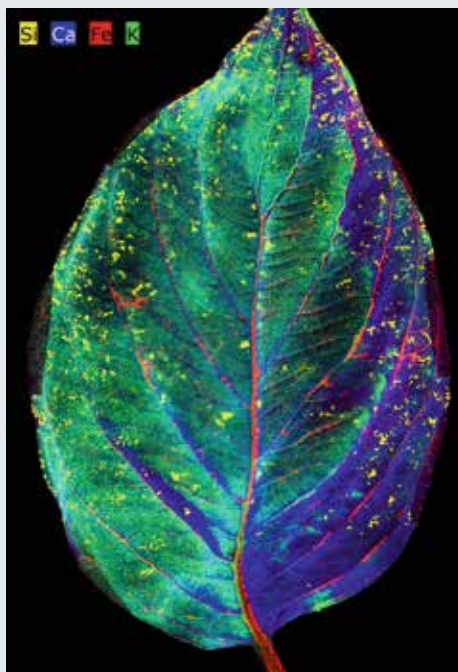
Element maps of an autumn leaf

Image size: 110 x 74.6 mm², scan resolution: 2200 x 1492 pixels, step size: 50 µm, dwell time: 10 ms/pixel.

The Powerful Software

Getting the most out of your measurement data

Our longstanding expertise in EDS analysis has been incorporated into the M4 TORNADO's powerful analysis software, which provides maximum functionality and ease of use.

Besides point and line scans our position tagged spectrometry option HyperMap allows high speed scans of areas. The complete spectroscopic information for each measured location is collected and saved in a multidimensional data cube, which allows comprehensive data evaluation. HyperMap supports extremely convenient data mining, both on- and offline.

HyperMap example performed on an iron meteorite

1 Video control with mosaic image, 10x/100x magnification

2 Mapping acquisition controls

3 Data evaluation tabs

4 Single element distributions

5 Data display with definable data access tools: line, point and objects
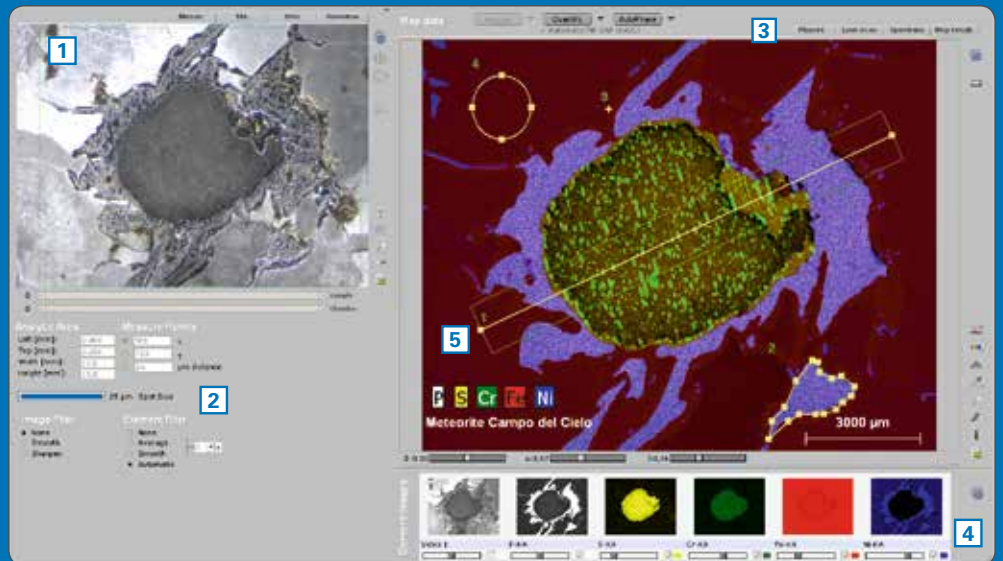
Data display options
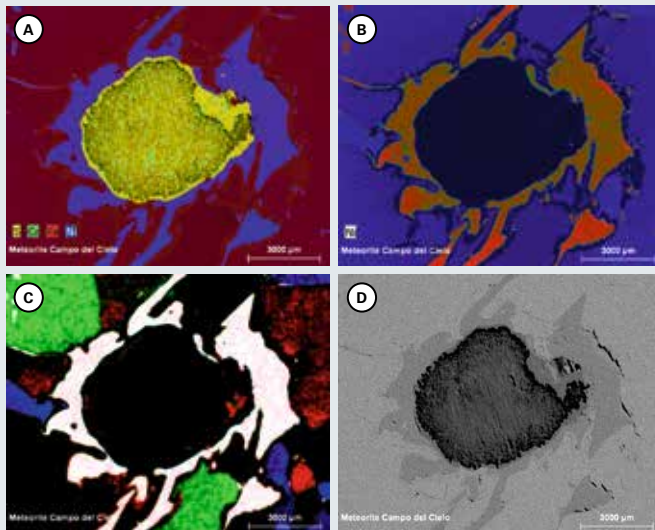
Analytical tools for mining the HyperMap data cube

Data display

Variable display options allow an optimized display of specific sample features: from multi-element display to variable intensities, crystal domain or density variations based on X-ray backscatter behaviour.

Data display: Multi-element mapping (A), false color element display (B), diffraction map showing the distribution of Bragg diffraction lines from specific crystal domains (C), total X-ray intensity map (D).

Information from points, lines and objects

Spectroscopic information can be extracted from a HyperMap data cube by using different data access tools such as definable objects, points or lines to analyze compositional differences within a measured area.

Point

This option provides a quick overview of major constituents at selected positions. Individual points can be set by placing crosshairs in the HyperMap image. The respective spectrum is displayed under the Spectrum tab.

Line scan

Within the HyperMap image arbitrary lines can be drawn to calculate the elemental composition. To improve statistics and to smooth element distribution lines, the software allows to broaden the scan line by adding adjacent pixels. The results of a scan are displayed under the Line scan tab.

Objects

Arbitrarily shaped objects (rectangles, circles, polygons) can be drawn in the map, resulting in a sum spectrum over the selected area. This function is extremely helpful to improve count statistics for quantification and for comparing similarly composed regions.
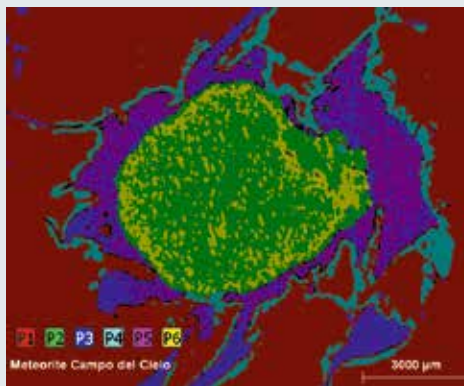
Phase analysis and chemometry

The phase analysis feature allows to determine the distribution and proportion of different phases within the scanned area.
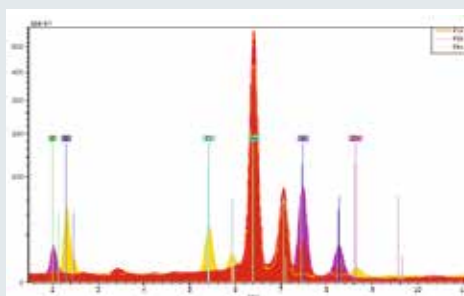
Line scan
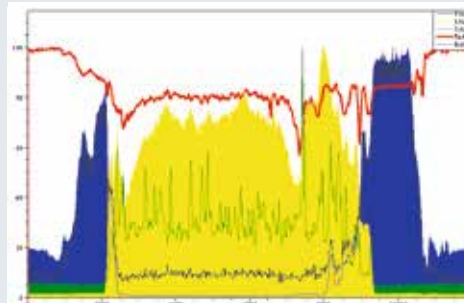
The line scan shows the relative intensity distribution of selected elements over the inclusion of an iron meteorite.

Phase analysis

Phase analysis clusters similar compositions as phases. The percentage share of each phase is calculated.

Spectra comparison

Spectra comparison between the phases of the figure above:
P1 – red
P5 – pink
P6 – yellow

Quantification

	Series	Net	[wt.%]	[wt.%]	Atom C [at.%]	Error [%]
Iron	K series	214751713	94,59	93,82	93,76	3,66
Nickel	K series	6274049	5,76	5,71	5,43	0,01
Copper	K series	7388	0,01	0,01	0,01	0,00
Zinc	K series	2017	0,00	0,00	0,00	0,00
Phosphorus	K series	89042	0,36	0,35	0,64	0,00
Sulfur	K series	37785	0,08	0,08	0,14	0,00
Chromium	K series	99229	0,03	0,03	0,03	0,00
		Total	100,82	100,00	100,00	

Quantification results of phase P1.

Technical Specifications

Sample types	Solids, particles, liquids
Sample chamber size	WxDxH: 600 mm x 350 mm x 260 mm
Stage	WxD: 330 mm x 170 mm Max. weight load: 5 kg
Measurement media	Air or oil free vacuum, ready for measurement within 100 s

Sample travel
   Max. travel
   Mapping travel
   Travel speed
	
	WxDxH: 200 mm x 160 mm x 120 mm
	WxD: 190 mm x 160 mm
	Up to 100 mm/s with TurboSpeed stage

Sample view	2 simultaneous live images from above with different magnifications for sample overview and precise positioning Lateral fisheye camera for the sample chamber overview
Excitation	High brilliance X-ray tube with polycapillary X-ray optics Optional: second tube with collimator

Excitation parameters
   Target material
   Tube parameters
   Spot size
   Filters
	
	Rh, optional: Mo, Ag, Cu, W
	50 kV, 30 W (40 W for collimator)
	Less than 25 µm for Mo-K with polycapillary lens
	Up to 5 filters

Detection	XFlash® silicon drift detector Optional: simultaneous use of 2 detectors

Detector parameters
   Sensitive area
   Energy resolution
	
	30 mm²
	< 145 eV at 300,000 cps
	(count rate Cu > 400,000 cps)

Instrument control	State-of-the-art PC, Windows 7
Instrument control functions	Complete control of tube parameters, filters, optical microscopes, sample illumination and sample positioning
Spectra evaluation	Peak identification, artifact and background correction, peak area calculation, quantification with standard-based and standardless models
Distribution analysis	"On the fly" measurement, HyperMap capability
Result presentation	Quantification results, statistical evaluation, element distribution (line scan, mapping)
Power requirements	100–240 V (1P), 50/60 Hz
Dimensions	WxDxH: 815 mm x 680 mm x 580 mm, 130 kg*
Quality & safety	DIN EN ISO 9001:2008, CE certified Fully radiation protected system; radiation < 1 µSv/h

*Depending on configuration

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