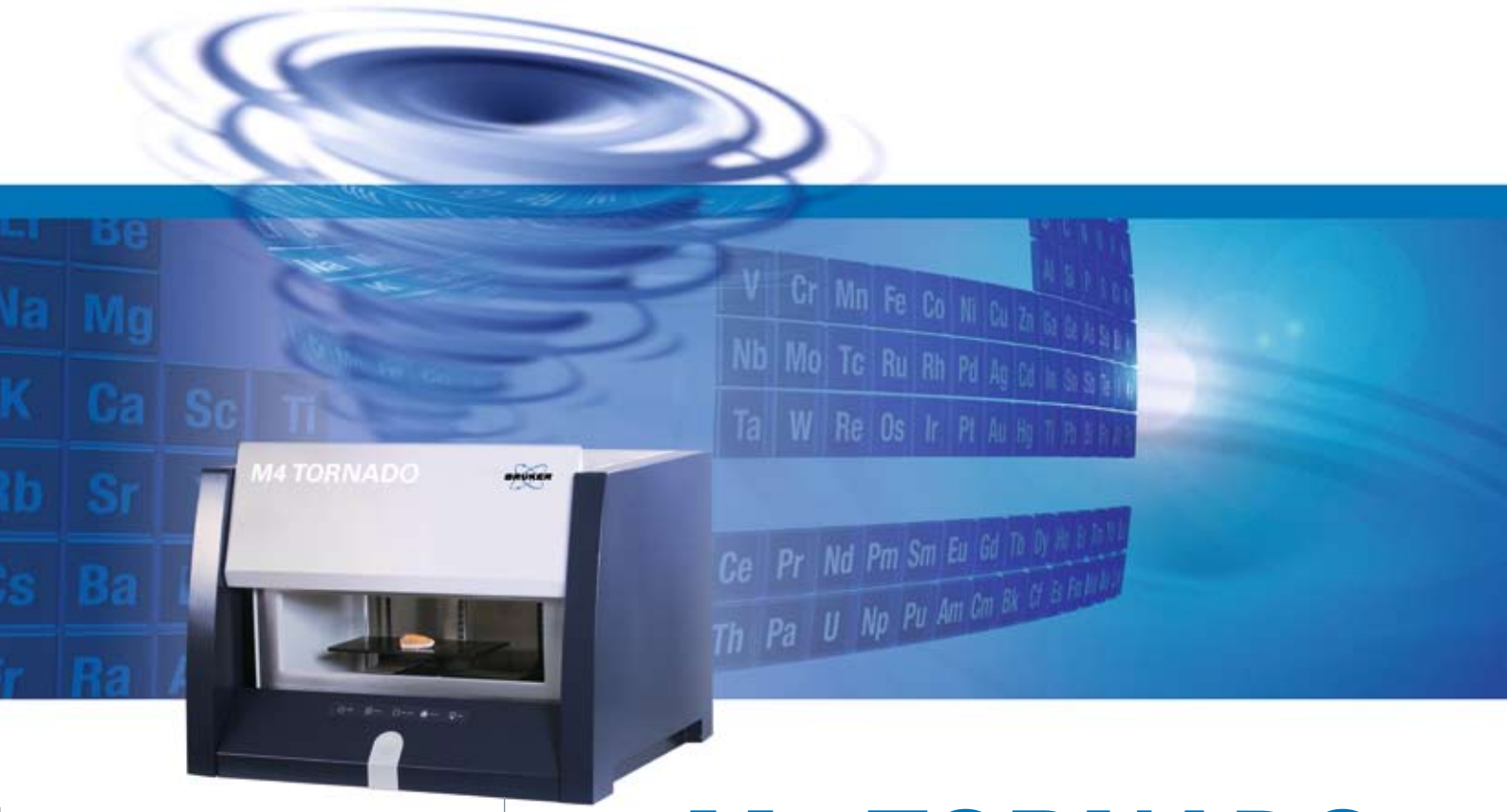


M4 TORNADO

- High performance µ-XRF spectrometer

µ-XRF

Innovation with Integrity

M4 TORNADO – Setting Standards in µ-XRF

µ-XRF is the method of choice for highly sensitive and non-destructive elemental analysis of diverse samples, including inhomogeneous and irregular 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 down to 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 of smallest sample areas. The X-ray optics allow to focus tube radiation from a large solid angle and concentrate it on spots down to 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 up to 500 kcps (single detector setup) combined with an energy resolution down to 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 200 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 of 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. Single frames with longer measurement time allow direct detailed analysis.

Convenience and ease of use

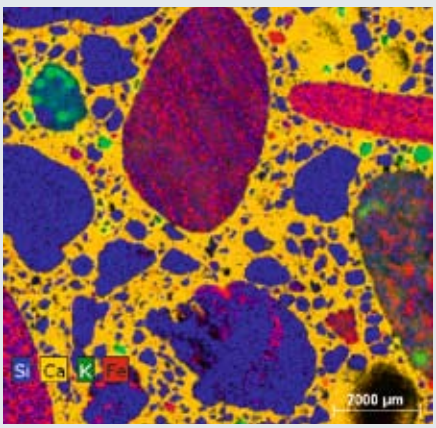
Convenience and easy handling are provided for the user through:

- The EasyLoad function for fast sample exchange
- The large sample chamber, enabling a stage travel of 200 x 155 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 cm^2) with 1 ms dwell time per pixel. Total measurement time: 3 min.

Applications

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.

Multi-element distribution analysis of a hidden painting

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.

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.

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.

Mosaic images of a PCB

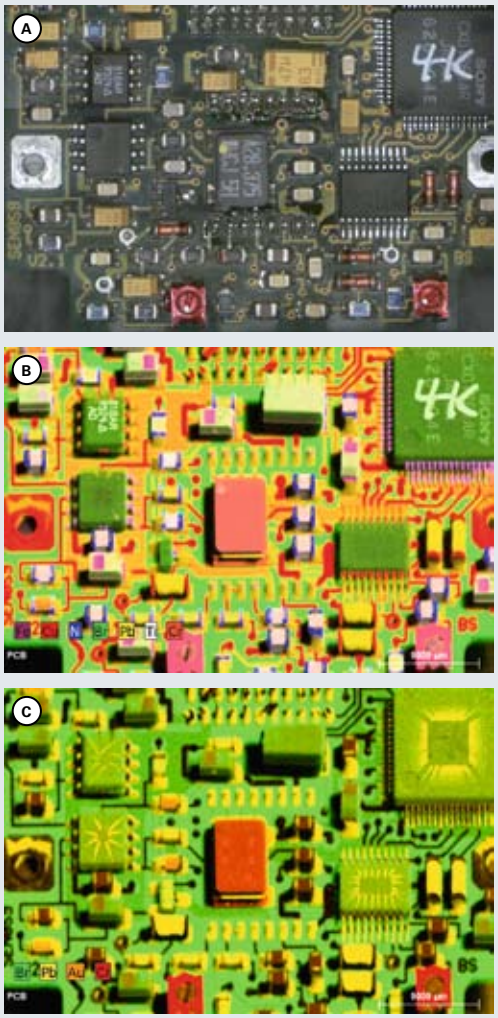


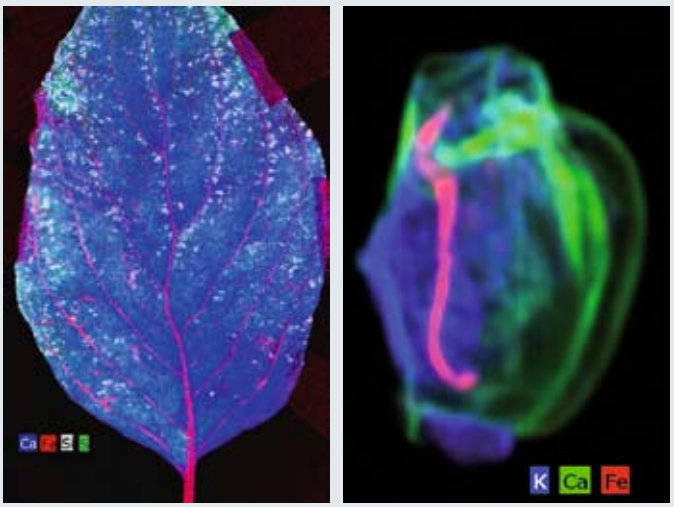
Image size: 44 x 28 mm², step size: 50 µm, scan resolution: 882 x 558 pixels, dwell time: 10 ms/pixel.
A – Mosaic image of the analyzed PCB.
B – Element distribution for several elements.
C – Element distribution for hazardous elements (Br, Pb, Cr) and for Au (showing the bond wires of the integrated circuits).

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 a dogwood leaf and a Daphnia



Left – Element map of a dried dogwood leaf prepared on Mylar film.
Image size: 70 x 46 mm², scan resolution: 900 x 588 pixels, step size: 75 µm, dwell time: 50 ms/pixel.
Right – Element map of a dried Daphnia prepared on a Mylar film.
Image size: 3.0 x 3.4 mm², scan resolution: 150 x 168 pixels, step size: 20 µm, dwell time: 100 ms/pixel.

The Powerful Software

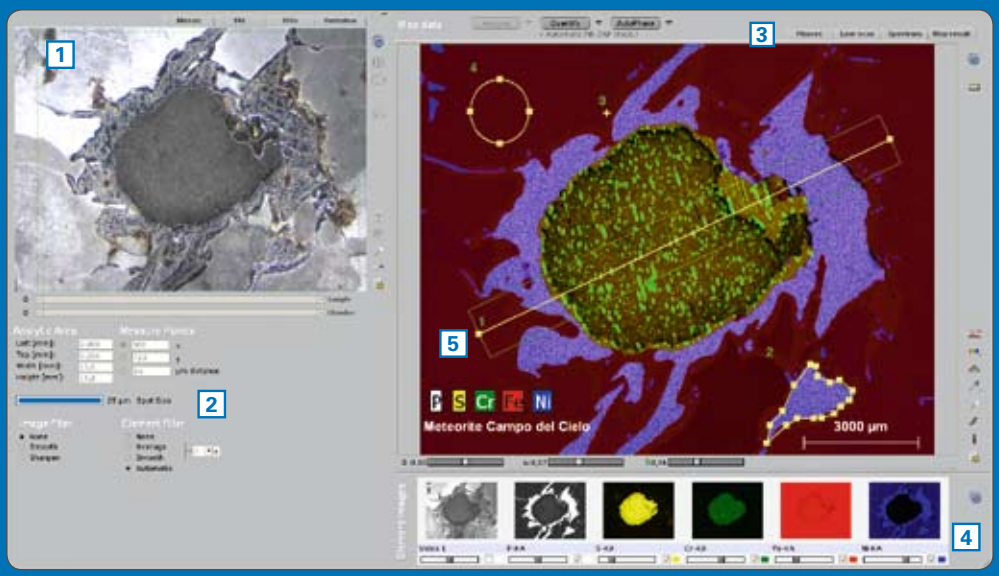
Getting the most out of your measurement data

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.

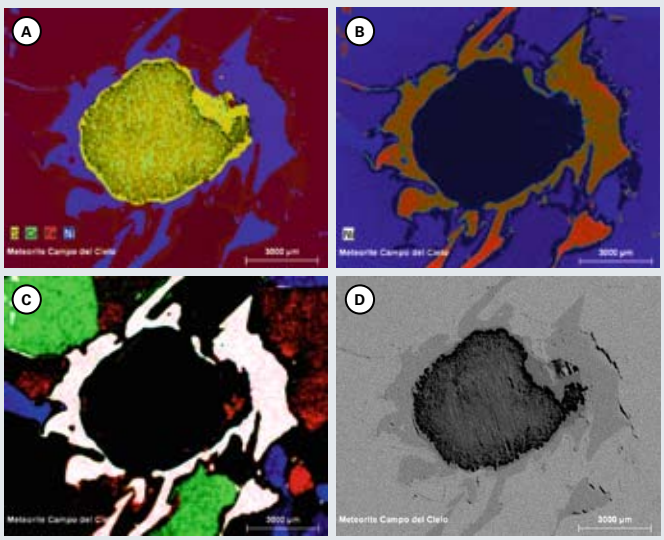
Besides point and line scans our position tagged spectrometry option HyperMap allows high speed scans of areas. The complete spectroscopic information for each measured location is collected and saved in a multidimensional data cube, which allows comprehensive data evaluation. HyperMap supports extremely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

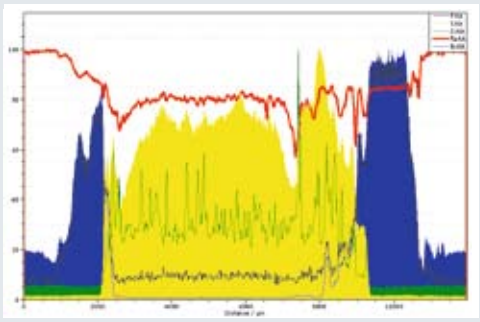
Objects

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

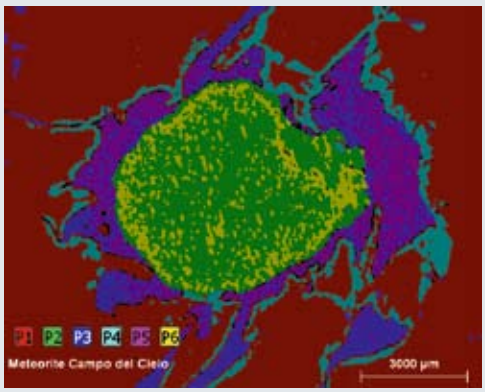
The phase analysis feature allows to determine the distribution and proportion of different phases within the scanned area.

Line scan



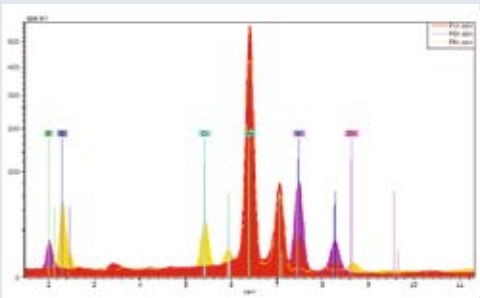
The Line scan shows the relative intensity distribution of selected elements on the inclusion of an iron meteorite.

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 x 350 x 260 mm
Stage size	WxD: 330 x 170 mm
Measurement media	Air or oil free vacuum, ready for measurement within 100 s
Sample travel Max. travel Travel speed	 WxDxH: 200 x 155 x 120 mm Up to 200 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: simultaneous use of 2 tubes
Excitation parameters Target material Tube parameters Spot size Filters	 Rh, optional: Mo, Ag, Cu, W 50 kV, 600 µA Less than 25 µm for Mo-K with polycapillary lens Up to 5 filters, according to customer requirements
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
Instrument control	State-of-the-art PC, Windows XP or 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 x 680 x 580 mm, 130 kg
Quality & safety	DIN EN ISO 9001:2008, CE certified Fully radiation protected system; radiation <1 µSv/h

Bruker Nano GmbH
Berlin · Germany
Phone +49 (30) 670990-0
Fax +49 (30) 670990-30
info@bruker-nano.de

Bruker Nano
Ewing, NJ · USA
Phone +1 (609) 771 4400
Fax +1 (609) 771 4411
info@bruker-nano.com

Bruker AXS Pte Ltd
The Helios · Singapore 138667
Phone +65 (6500) 7288
Fax +65 (6500) 7289
info@bruker.com.sg

www.bruker.com

Sales representative: