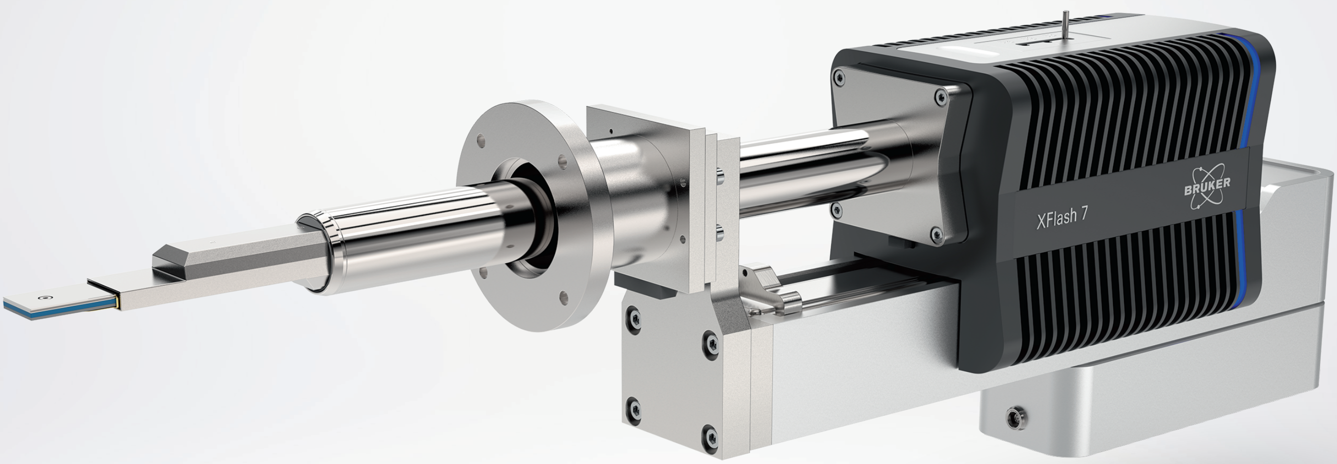


EDS

QUANTAX FlatQUAD

EDS for SEM with the XFlash® FlatQUAD Detector

Innovation with Integrity

XFlash® FlatQUAD – Maximum Efficiency in X-ray Detection

QUANTAX FlatQUAD is the EDS microanalysis system based on the revolutionary XFlash® FlatQUAD detector. This special annular four-channel silicon drift detector is inserted between SEM pole piece and sample, achieving maximum solid angle in EDS. In combination with the comprehensive ESPRIT software suite, QUANTAX FlatQUAD systems provide previously unheard of analytical performance, even for the most challenging samples.

Employing latest detector technology

The XFlash® FlatQUAD detector, the core of the Bruker QUANTAX FlatQUAD system, is based on a novel detector concept. This includes positioning the detector from the side between pole piece and sample. Therefore, the detector is mounted on a horizontal port on the SEM chamber. Conventional detectors, which rarely extend beneath the pole piece require an inclined port. To ensure compatibility with many different SEM types, the XFlash® FlatQUAD detector can be precisely positioned in X, Y and Z direction.

The four independent silicon drift detector segments of the XFlash® FlatQUAD are arranged annularly around a central aperture in the detector module. The primary electron beam passes through this opening. The materials the detector is constructed from, were chosen to avoid influences on the electron beam.

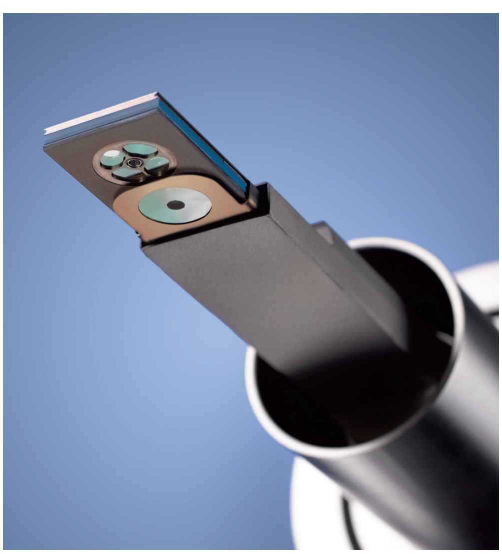
This design as well as the intention to keep the detector finger as thin as possible require a new method to prevent backscattered electrons from reaching the detector chips. The detector is equipped with special polymer windows of varying thickness. They absorb the backscattered electrons while allowing X-rays to pass through. The polymer windows are mounted in a slider which permits changing them without affecting the vacuum. This enables SEM acceleration voltage changes while the detector is in measurement position.

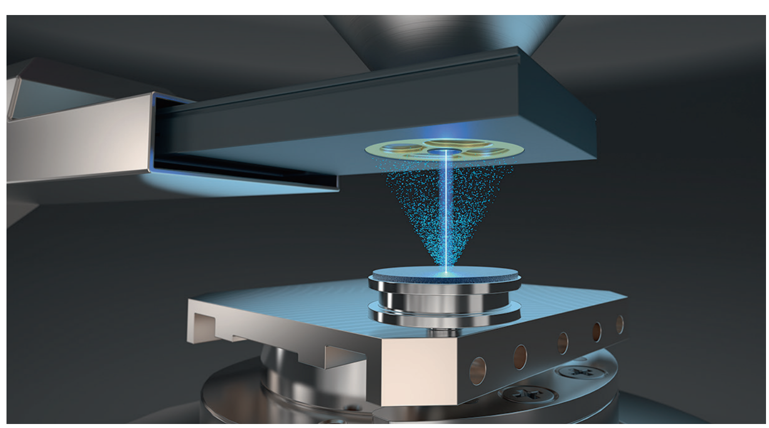
Functional principle

The XFlash® FlatQUAD is a side entry detector. It is positioned between SEM pole piece and sample. The primary electron beam can pass through the center hole around which the four detector segments are arranged. The solid angle for radiation collection that can be achieved depends on the distance between detector and sample. It can be varied by using the Z drive of the SEM stage. A set of included electron absorbing polymer windows can be changed in situ.

Figure 1 (bottom left)
Close up on the XFlash® FlatQUAD detector layout.

Figure 2 (bottom right)
Visualization of the XFlash® FlatQUAD functional principle.





Taking EDS to New Limits

Elemental analysis with EDS in SEM can be challenging when dealing with complex and difficult samples, such as beam-sensitive materials, biological and life science thin sections, semiconductor devices, battery materials, FIB/TEM lamellae, nanoparticles and samples with topographical features or heavy surface charge (i.e., glass and ceramics).

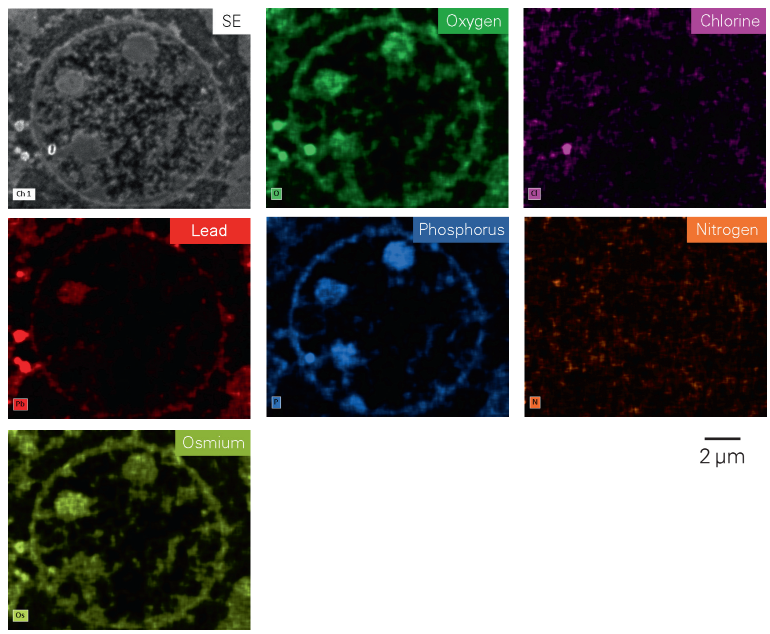
The XFlash® FlatQUAD is an EDS micro- and nano-analysis detector that performs where conventional systems reach limitations. Maximum signal collection is ensured by its annular four segment SDD design, the placement under the pole-piece, and the high take-off angle. Extremely fast mapping at the highest output count rate (OCR) can be achieved with moderate beam currents.

The XFlash® FlatQUAD enables unmatched sensitivity, even at low (< 3 kV) voltages and ultra-low probe currents (< 50 pA). These beam conditions are required for challenging samples and cannot be achieved with conventional single or even multiple large-area EDS detectors with inclined geometry.

Human cell studies

The XFlash® FlatQUAD helps to explore the structure, function, and behavior of cells, essential for understanding biological processes, offering crucial insights into health and disease mechanisms.

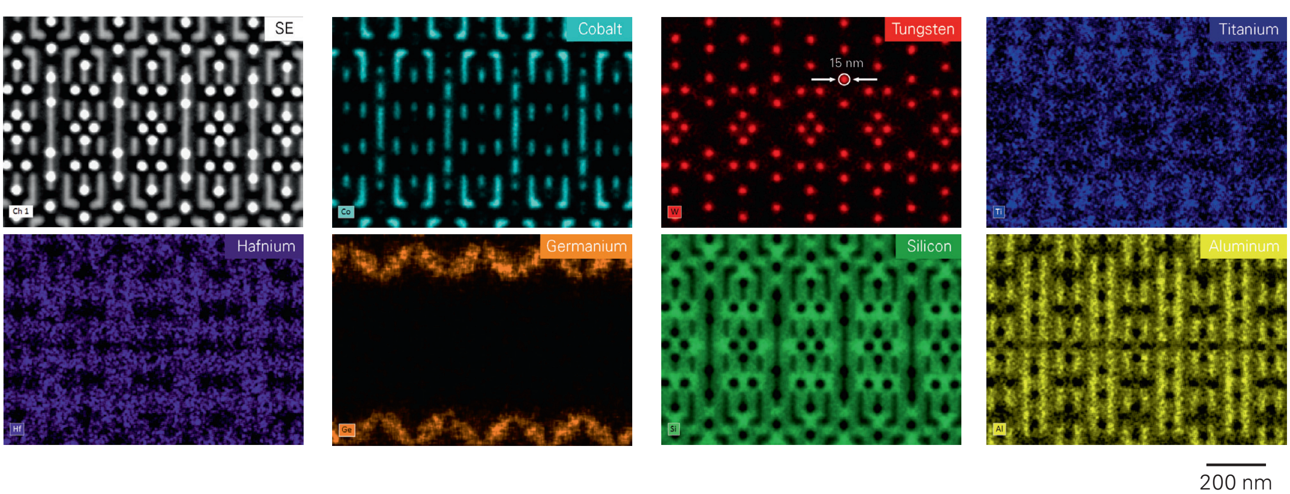
Figure 3
Elemental maps of 100 nm thin resin cross section of cancer cells acquired at 5 kV, 580 pA, and output count rate (OCR) of 109,800 cps.



Semiconductor analysis

The continuous miniaturization of semiconductor structures requires their understanding at the nanoscale to ensure suitable design and failure analysis. Chemical mapping of semiconductors with SEM EDS is challenging as it requires high resolution to resolve feature below 10 nm. The QUANTAX FlatQUAD system is the best choice to ensure the resolution of the microscope with optimal solid angle X-ray flux.

Figure 4
Ultra-high resolution SEM EDS map of a bulk FinFET device acquired at 5 kV and 1.1 nA with output count rates (OCR) of 309,000 cps.



Meeting the Greatest Analytical Challenges

Charging samples – high pulse throughput and low probe current

Thanks to the extremely large solid angle of the XFlash® FlatQUAD detector, QUANTAX FlatQUAD systems support convenient analysis of samples that are difficult or even impossible to investigate using conventional systems, as it already starts performing with beam currents in the pA range:

- Sensitive samples can be analyzed without electron beam damage.
- Non-conducting specimens can be investigated under high vacuum without carbon coating. Compared to low vacuum analysis, this approach reduces hydrocarbon contamination and avoids beam skirting effects.
- Samples with low carbon content can be analyzed, as carbon deposition caused by the electron beam is drastically reduced and result falsification avoided.
- Valuable samples (e.g., cultural heritage objects) can be analyzed in their original state without destructive sample preparation.

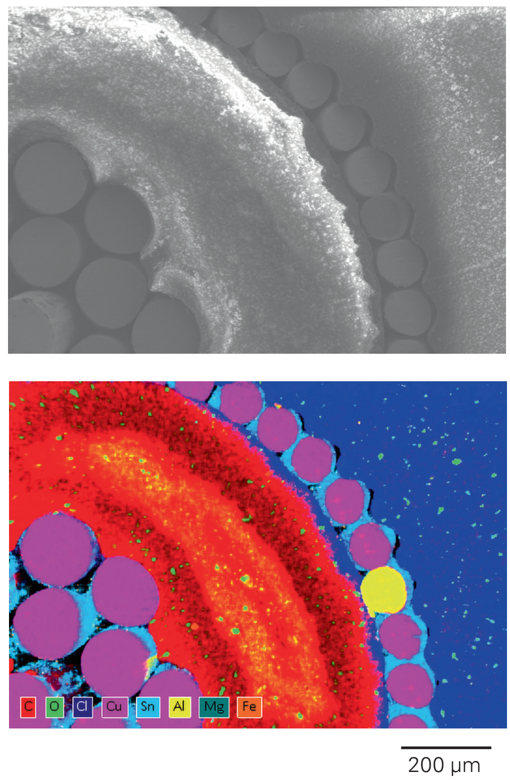


Figure 5
SEM image and elemental map of insulating layers of a cable sample acquired in high vacuum conditions at 5 kV, 237 pA, and 71,600 cps OCR.

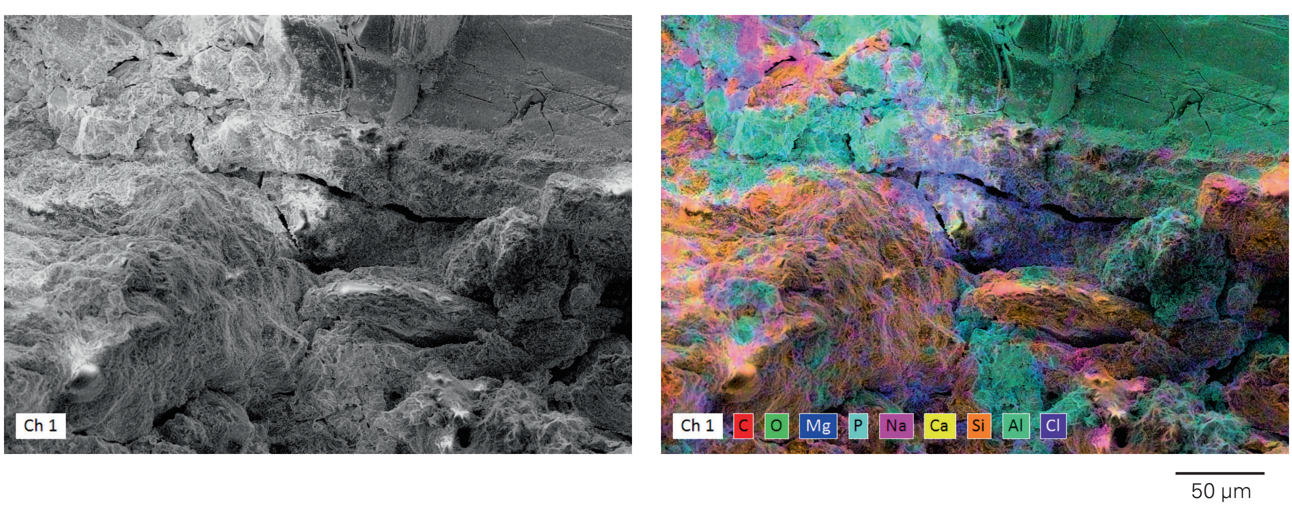
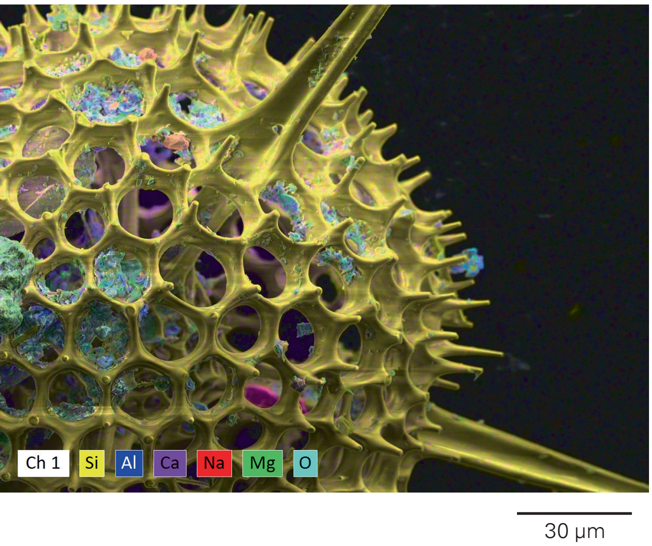


Figure 6
SEM image and elemental map of a heavily charging pharma tablet measured at ultra-low probe currents < 18 pA and 3,100 cps OCR.

Ideal for Complex Topographical Samples



Minimal shadowing effects

Conventional large-area inclined EDS detectors are at a disadvantage when it comes to mapping samples with topography, as their view from one side restricts them from detecting radiation from all parts of the sample – shadowing occurs.

The XFlash® FlatQUAD detector with its four detector segments positioned directly above the specimen is affected far less by this phenomenon. This permits complete investigation of all sample areas hit by the electron beam.

Figure 7 (left)
5 kV SEM EDS map of a highly topographic and curved surface of a Radiolaria. The annular four-segment detector design enables signal collection from all four sides of the sample.

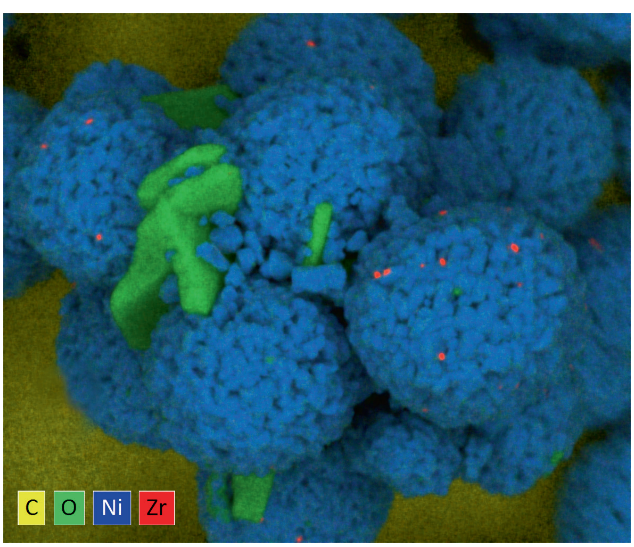
Battery materials

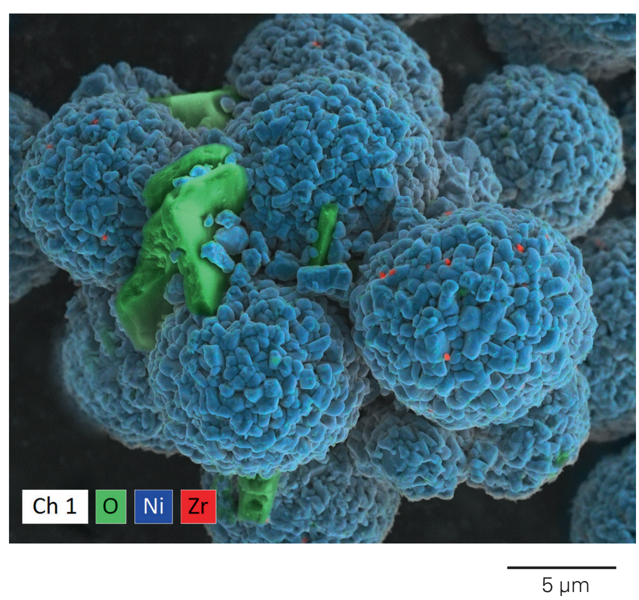
EDS-based analysis of battery materials for research and in industry identifies the elemental composition, crucial for understanding material properties, performance, and degradation.

A key application is the failure analysis of such materials. This is important for the identification of mechanical, chemical, and thermal defects and mechanisms to improve safety, reliability, and lifespan of energy storage systems.

The XFlash® FlatQUAD's four-segment annular design minimizes shadowing-related data and information losses for identifying contamination in a material, overcoming this limitation for conventional EDS detectors.

Figure 8
NCM (nickel-cobalt-manganese) battery precursor material with Zr contamination (red). Left: X-ray map with only minimal shadowing matching the topography of the SEM image, which is not achievable with a conventional inclined EDS detector. Right: Elemental map with overlayed SEM image.



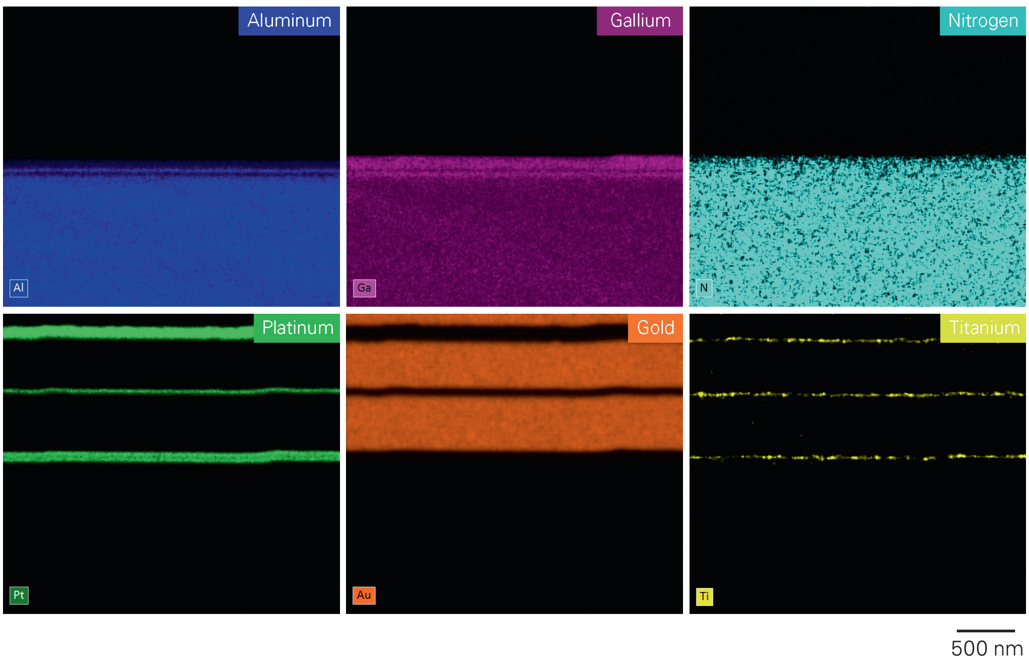


Advanced Spectral Imaging

Electron transparent samples

XFlash® FlatQUAD gives users the ability to perform TEM-like EDS measurements on electron transparent samples in SEM. This allows for high-resolution EDS without the complex sample preparation and conditions required for a TEM.

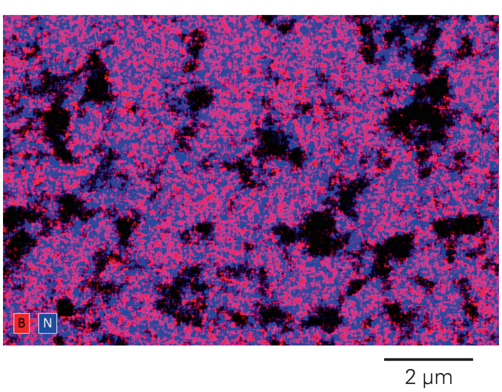
Figure 9
Chemical distribution map of a 50 nm thin FIB/STEM lamella from AlGaN LED semiconductor device acquired at 5 kV, 960 pA, with 218,400 cps OCR.

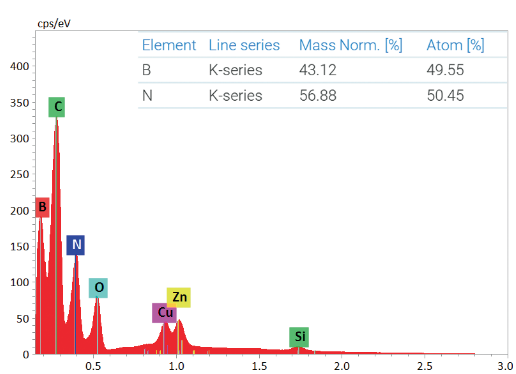


Quantification with XFlash® FlatQUAD

Accurate elemental quantification is possible using the XFlash® FlatQUAD, allowing users to determine the elemental composition of their samples.

This enhances material characterization, improves quality control and supports advanced research and development in many scientific and industrial applications.





Element	Line series	Mass Norm. [%]	Atom [%]
B	K-series	43.12	49.55
N	K-series	56.88	50.45

Figure 10
Quantification of BN sample embedded in a brass block. The 3 kV measurement shows the B to N ratio of 1:1, which matches the expected composition.

Highest Sensitivity EDS Detector

Best solid angle in EDS for SEM

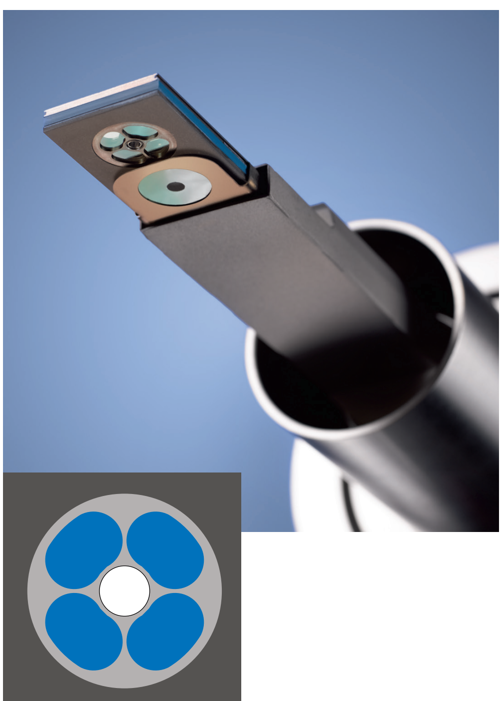
The positioning of the detector chips provide the largest solid angle for X-ray collection in a SEM. Depending on the specific geometrical conditions more than 1 sr is possible in combination with a high takeoff angle of 60° or more.

The active area of the detector chips is approximately kidney-shaped to provide optimum solid angle and detector resolution at the same time. The anode and on-chip preamplifier are positioned to one side out of the irrediated area for improved performance. The segments are protected by an on-chip 1 µm polymer window.

No compromise between count rate and energy resolution

The collection efficiency can lead to ultrahigh count rates. All four detector chips are therefore equipped with separate signal processing channels. This allows input count rates (ICR) of up to 8,000,000 cps and a combined output count rate (OCR) of up to 3,200,000 cps.

Bruker's expertise in SDD technology makes XFlash® FlatQUAD available with an excellent energy resolution of 127 eV at Mn Kα. Resolution classes of 129 eV and 133 eV are also available.



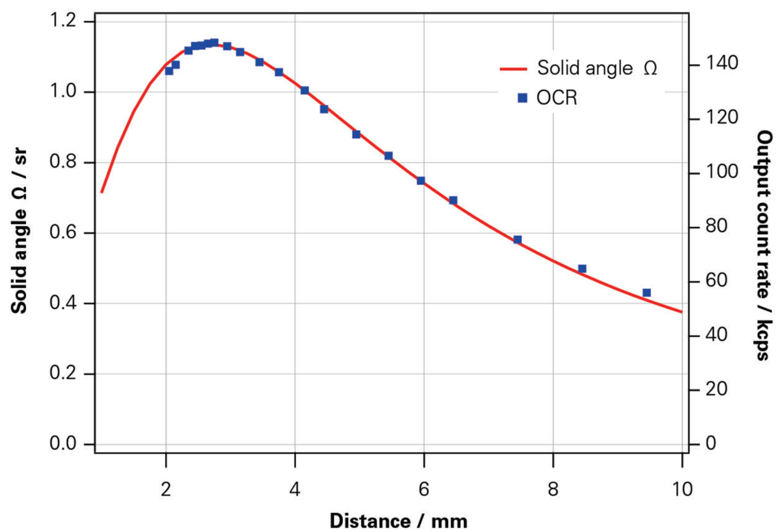
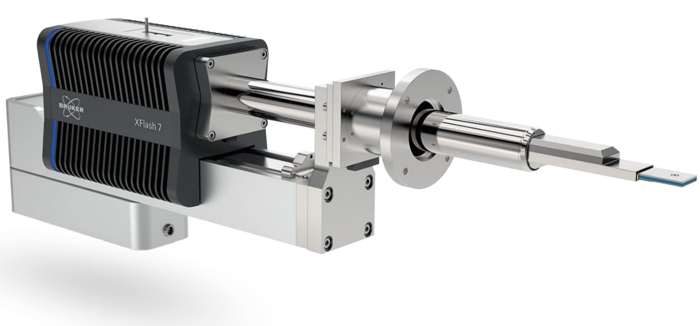


Figure 12
Solid angle and OCR as function of the detector-sample distance achieved on copper at 5 kV accelerating voltage and 1 nA beam current; theoretically calculated according to N.J. Zaluzec, Detector Solid Angle Formulas for Use in EDS, Microsc Microanal. 15 (2009), 93.

Figure 11
XFlash® FlatQUAD detector finger and schematic detector layout showing the annular arrangement of the four detector segments.



Technical Data

Parameter	Specifications
Energy resolution	Available energy resolutions: 127 eV, 129 eV, 133 eV at Mn Kα
Element range	Boron (5) to californium (98), for further details see table below
Input count rate	Up to 8,000,000 counts per second (cps)
Output count rate	Up to 3,200,000 cps
Analytical solid angle	Up to 1.1 sr independent of SEM
Take-off angle	Working distance dependent, freely adjustable between > 40 ... 90 degrees
Maximum detector insertion/ retraction speed	10 mm/s at an accurancy of ± 25 µm
Cooling	Liquid nitrogen-free Peltier cooler, vibration-free
Operating pressure	Max. 30 Pa
Electron filter	3-position electron filter to be used for different acceleration voltages, see also table below
SEM compatibility	Minimal interference with SEM through use of non-magnetic materials
Safety features	The following interlocks are available: XFlash® FlatQUAD detector position and temperature monitoring, SEM stage travel range, SEM vacuum level

Energy filter options for the XFlash® FlatQUAD*

Maximum SEM high voltage	Window type	Low energy performance
6 kV	Fixed on-chip	B, C, N, O, F
12 kV	Additonal 2 µm polymer window	B, C, O, F, N near limit of detection (LOD)
20 kV	Additional 6 µm polymer window	F near limit of detection

* Other window options available on request.

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Electron Microscope Analyzers
Bruker Nano GmbH
Berlin · Germany
info.ema@bruker.com

www.bruker.com/quantax-flatquad