XFlash® 7 – The New EDS Detector Series

info.bna@bruker.com

BRUKER

XFlash® 7 – The right angle for better analysis

Fast. Precise. Reliable.

XFlash® 7 - the detector
for SEM and FIB-SEM

XFlash® 7T - the detector
for TEM and STEM
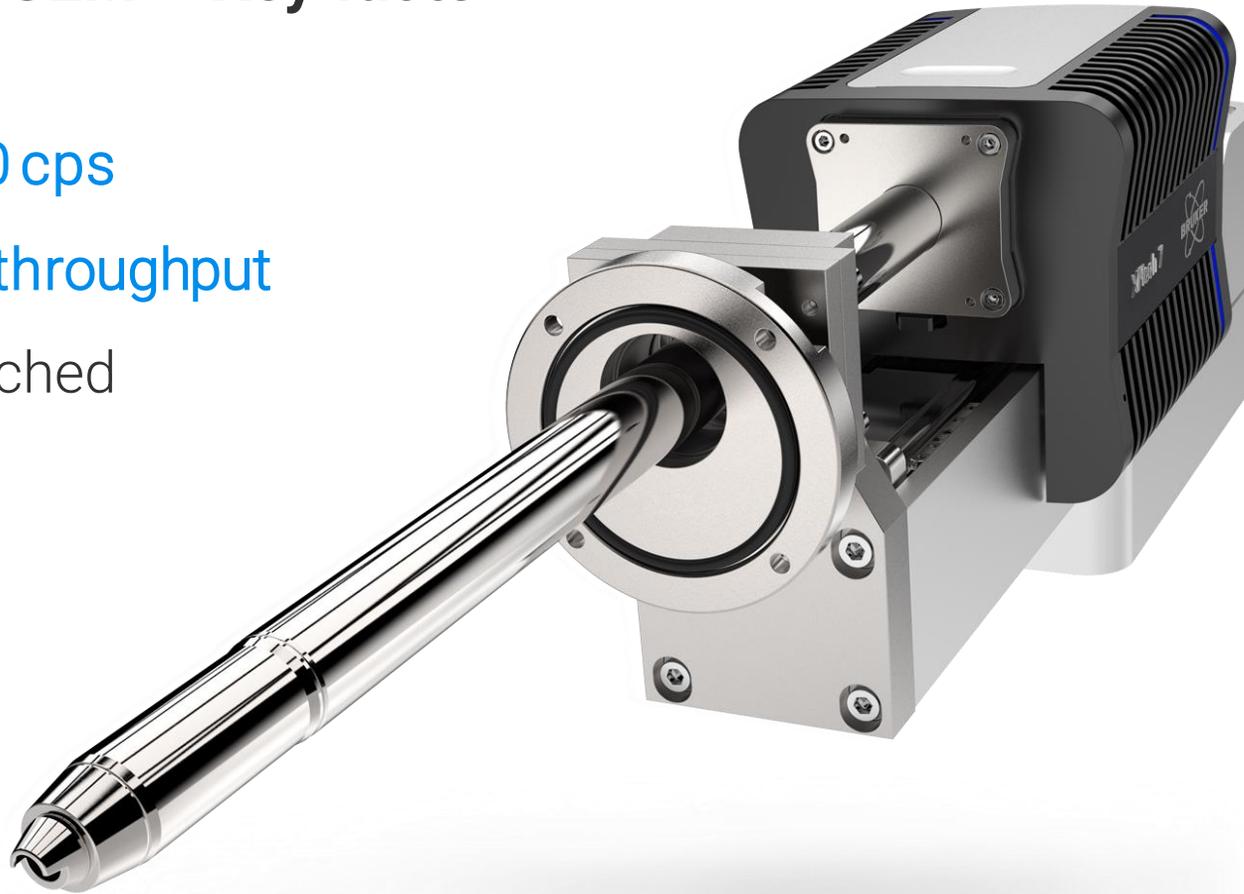
XFlash® 7 for SEM – Key facts

Up to 1,000,000 cps

Real analytical throughput

Achieve unmatched analysis speed

> 1.1 sr

Largest solid angle for X-ray collection

Maximize sample throughput with optimum geometry for most efficient collection of the generated X-rays

> 2,200

Element lines

Quantify complex data using the most comprehensive atomic database incl. K, L, M and N lines

XFlash® 7 – Benefits

Make your element analysis more efficient

- Individually optimized EDS systems to provide unmatched speed and precision.

- Shorten measurement time with maximized throughput.

- The most efficient geometry for collection of generated X-rays to analyze challenging samples.

- Benefit from accurate and reliable quantification results with optimized geometry.

- Detect smaller quantities of matter thanks to optimized detector geometry leading to lower background and less absorption.

XFlash® 7 – Benefits

Get the most out of your system and uptime
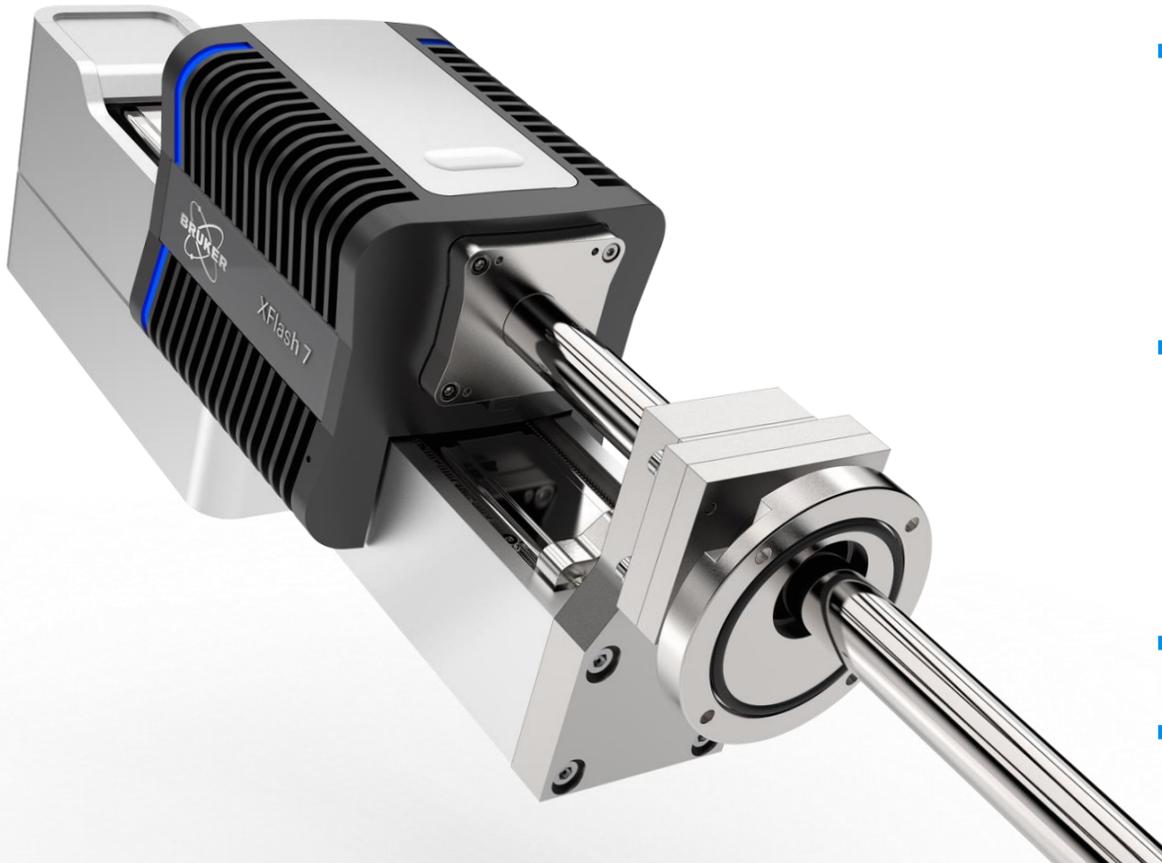
- One for all - seamless integration of EDS, WDS, EBSD, and micro-XRF in the comprehensive ESPRIT analysis platform. Available for any SEM, FIB-SEM and EPMA allowing users to switch easily between techniques.

- Maximize system uptime and ensure data integrity with on-demand health check. Tracking the detector parameters and allowing predictive maintenance to expand detector lifetime.

- All components can be exchanged on-site

- Applicable to many market segments, e.g., Material or Life Science research and Semiconductor industry.

XFlash® 7 – Be faster!

With up to 1,000,000 cps the XFlash® 7 offers the highest real analytical throughput on the market for EDS detectors, meaning:

- Acquire quantitative EDS data at any speed using the new ESPRIT Live Map

  https://www.youtube.com/watch?v=DF-XBmIIGI8

- Get best results in the shortest time

- No risk of signal loss caused by slow read-out electronics

- Maximize your sample throughput without compromising quality

- Avoid tweaking microscope parameters
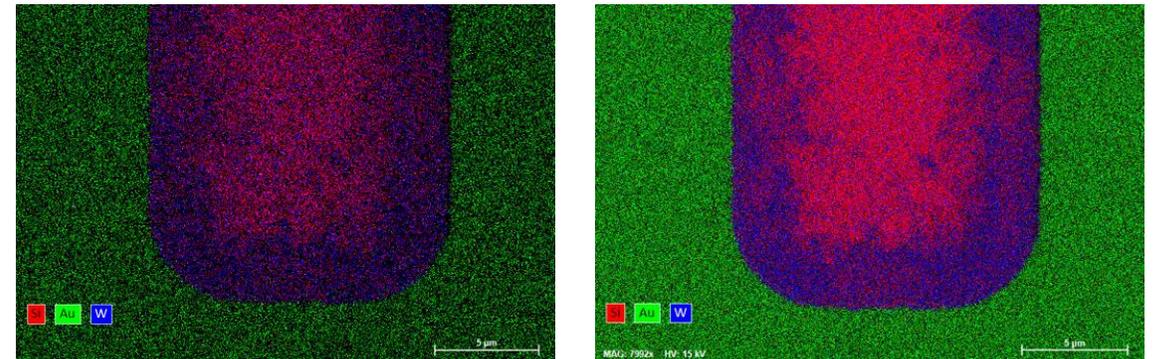
Element distribution maps based on deconvolved net intensities of Si-K and W-M lines at 15 kV.

| Measurement conditions	Left	Right
Detector	Conventional detector	XFlash® 760
Measurement time	7 s (1 frame)	7 s (1 frame)
Input count rate	63 kcps	700 kcps
Dead time	18 %	38 %

XFlash® 7 – Be faster!

Fast elemental mapping of Si and W wafer etching residues
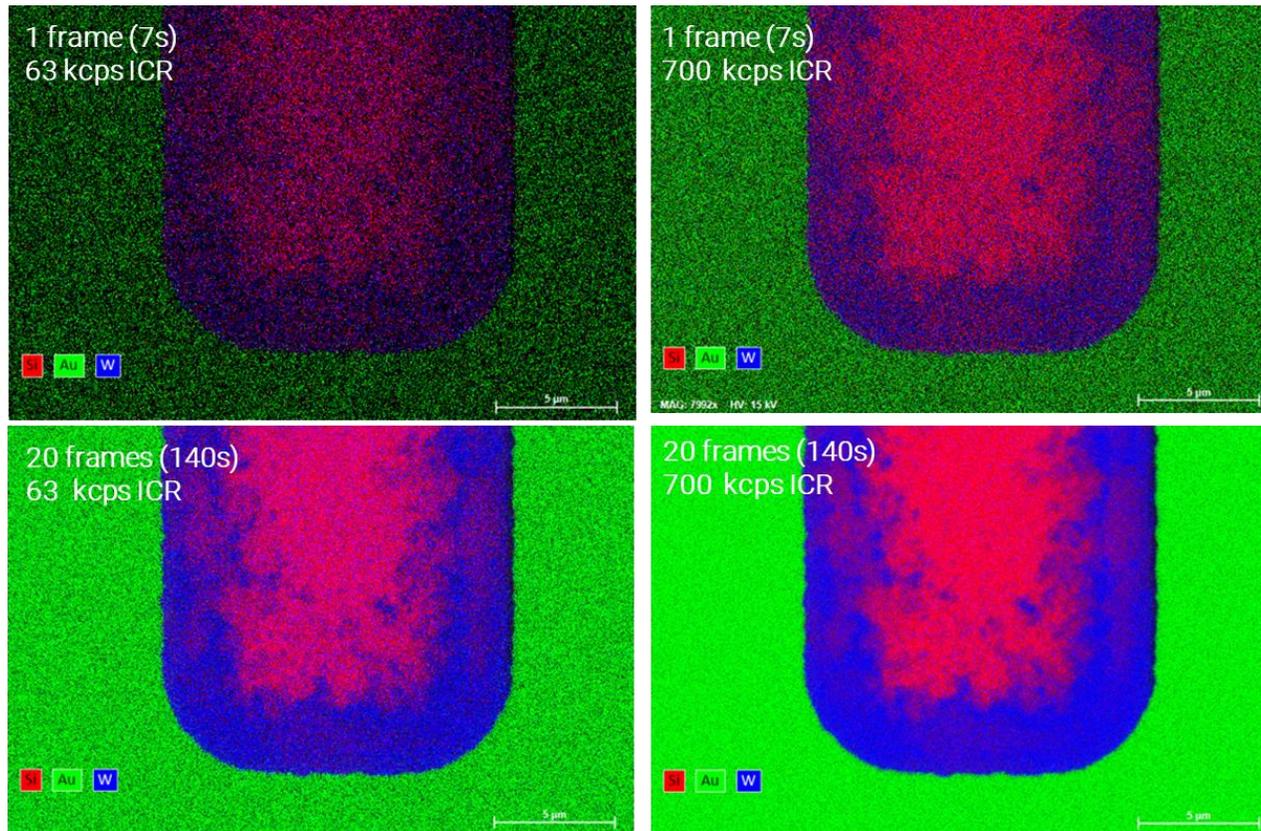
Benefits of mapping at very high throughput

- High count statistics in maps
  → no map filtering necessary

- Online deconvolution at high speed
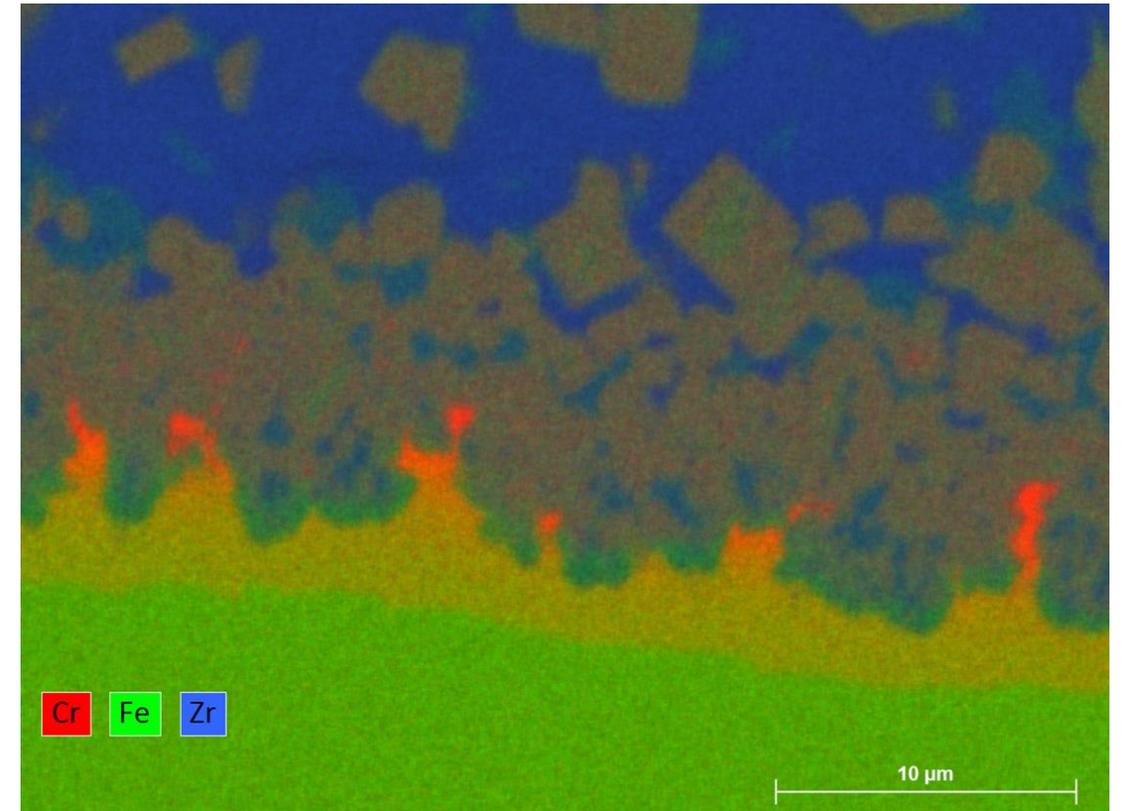 → real distribution of Si and W visualized in a very short time
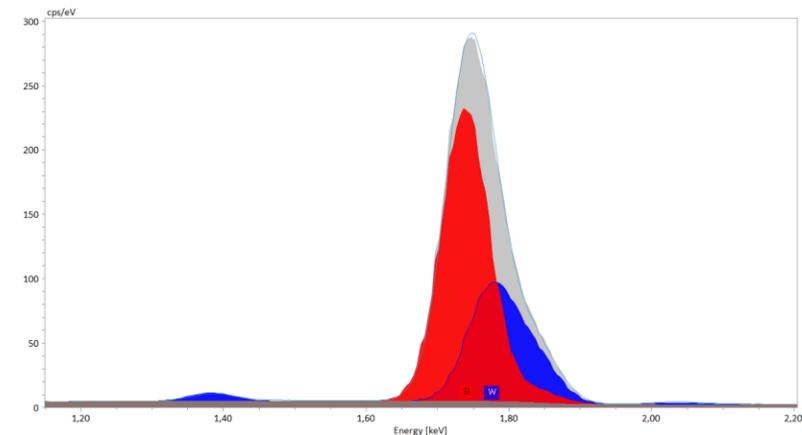
W residues on etched Si at 15 kV. No image filter. Online deconvolution of overlapping Si-K and W-M lines.

XFlash® 7 – Be faster!

High throughput element mapping of Zr-steel welding seam
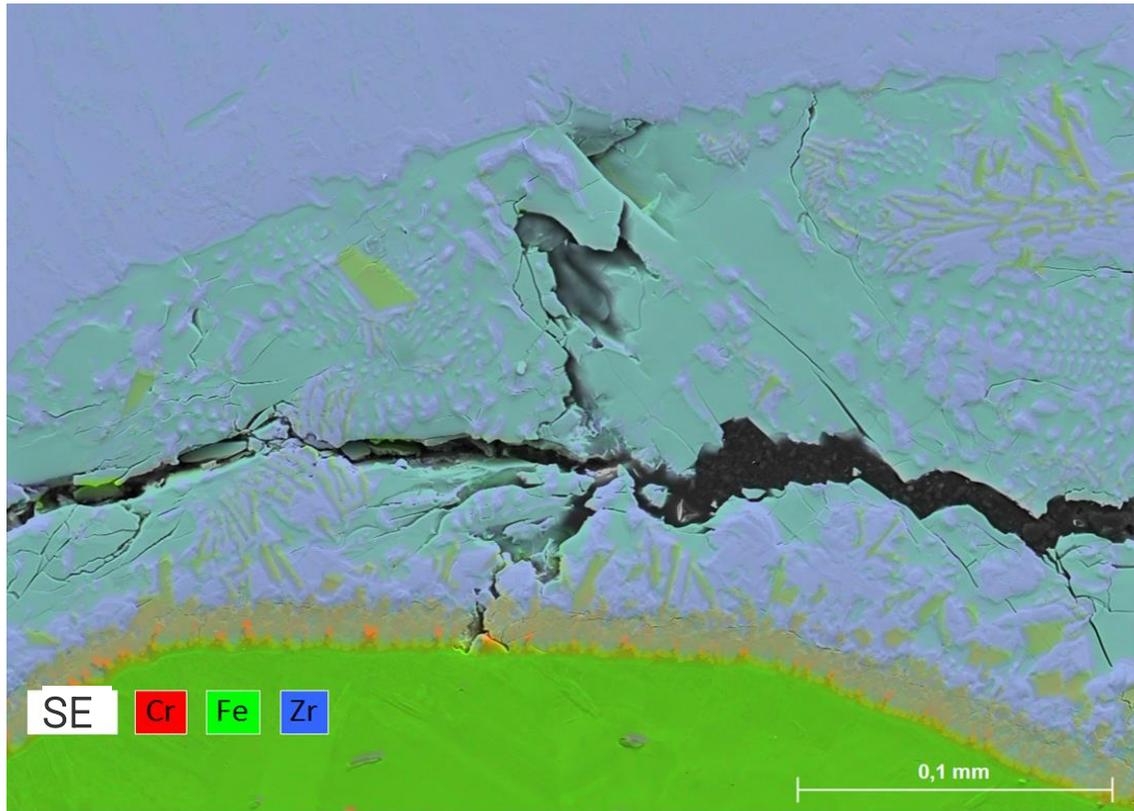
**ICR: 2.25 Mcps, OCR: 900 kcps,** Mapping time: 11 mins

ICR: 1.375 Mcps, OCR: 550 kcps, Mapping time: 5 mins

Maps acquired at HV=15 kV, using high beam current producing a very high X-ray count rate.

XFlash® 7 – Get precise results!

The most comprehensive atomic database including more than 2,200 element lines leads to an unrivaled quality in ESPRIT peak ID and separation, meaning:

- Advanced peak deconvolution algorithms enables online (live, during acquisition), and offline visualization of overlapping elements

- The combination of good resolution with best deconvolution means even close overlaps can be resolved with confidence

- Best quantification results also for challenging samples using low accelerating voltages
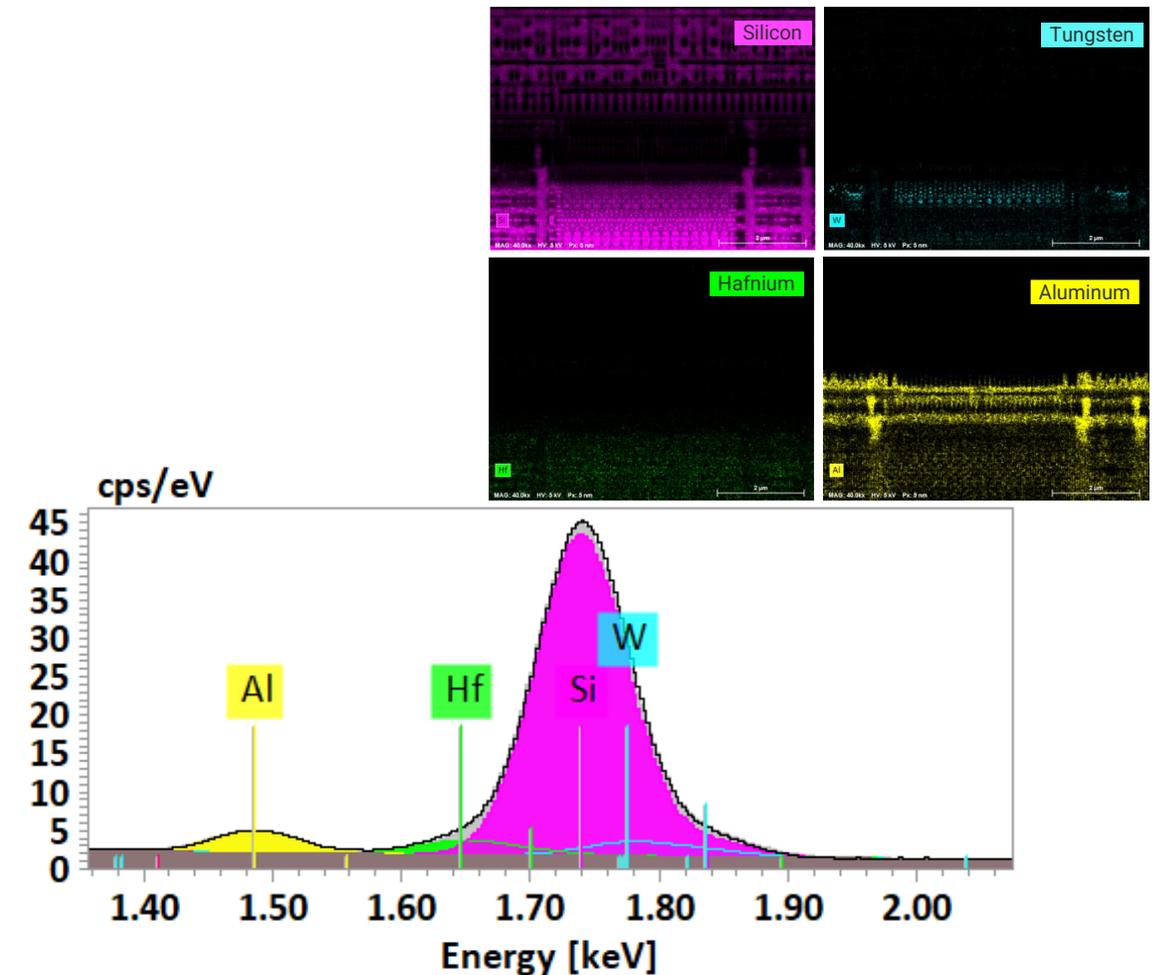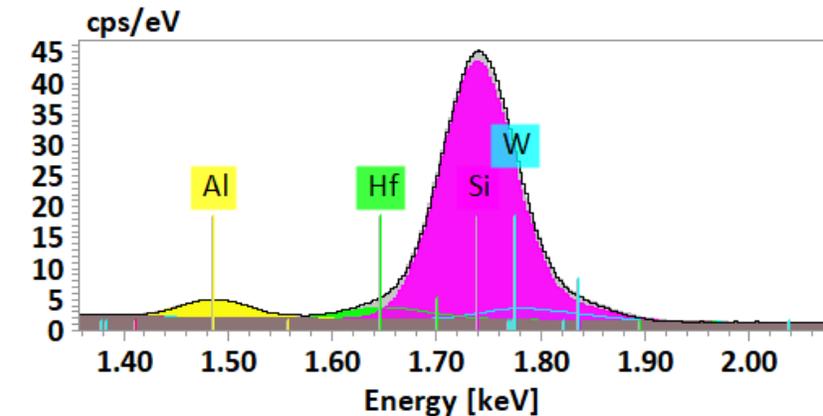

Automatically deconvolved heavily overlapped lines.

XFlash® 7 – Get precise results!
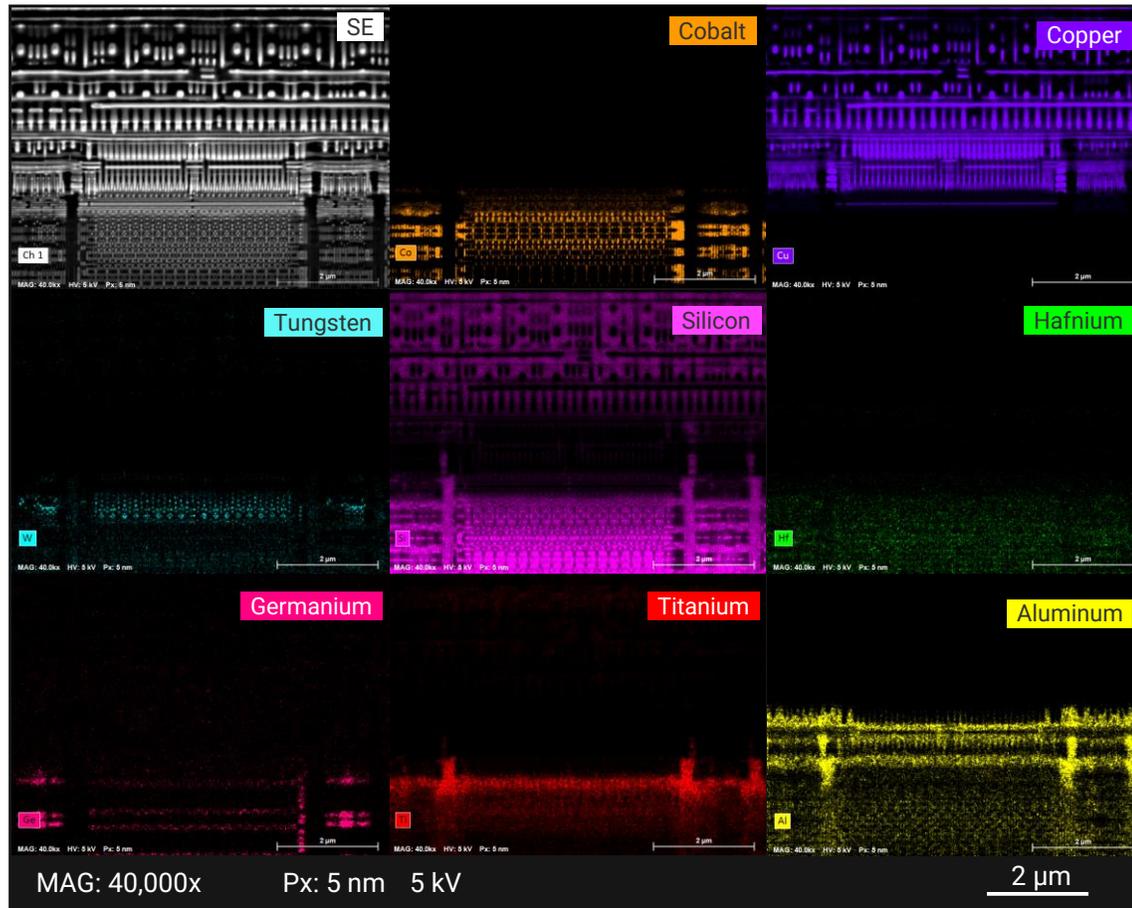
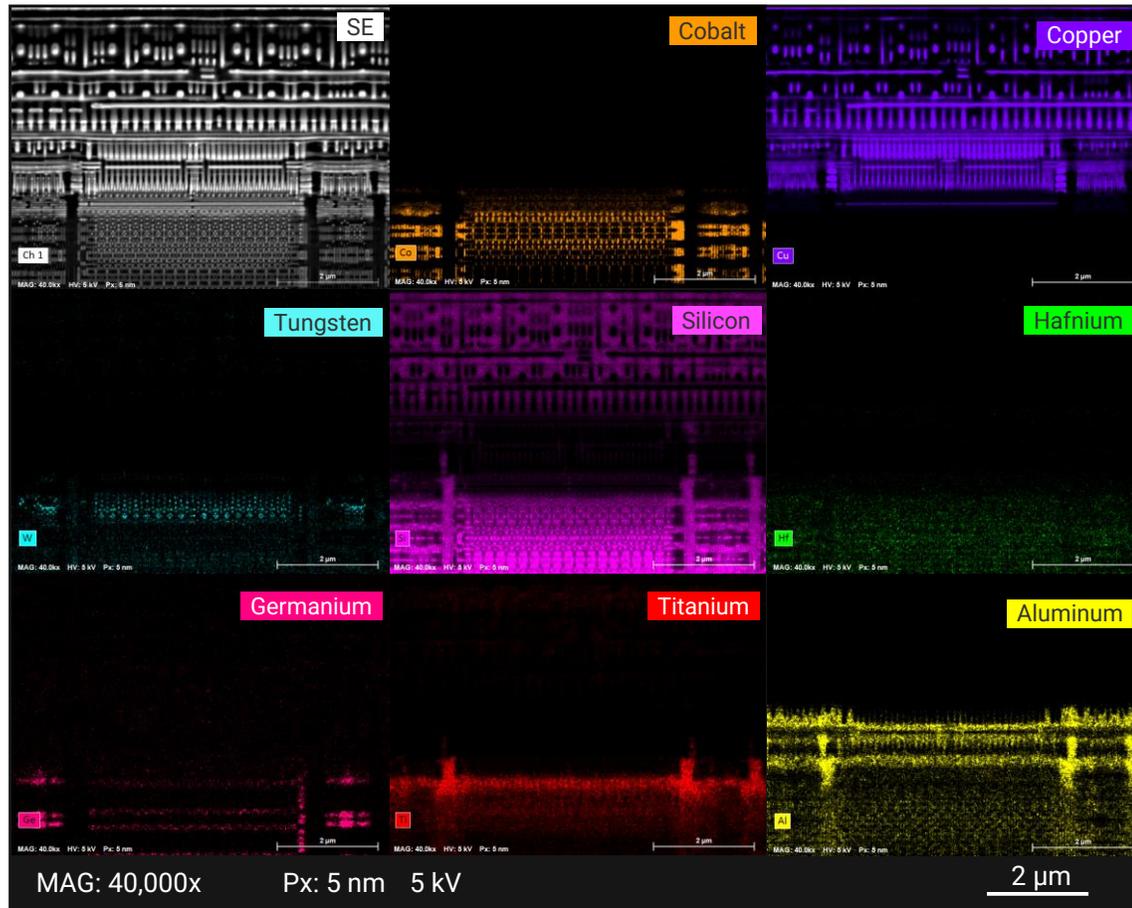## SEM EDS analysis of bulk 7 nm process FinFET

- Semiconducting IC chip (FinFET) delayered with FIB

- Low kV, EDS spatial resolution ~10 nm (theoretical bulk lateral resolution), Si-W-Hf peak overlaps deconvoluted

- XFlash® 7 features: High collection angle ideal for low X-ray yield samples - SNR

XFlash® 7 – Get precise results!

## SEM EDS analysis of bulk 7 nm process FinFET

- Semiconducting IC chip (FinFET) delayered with FIB

- Low kV, EDS spatial resolution ~10 nm (theoretical bulk lateral resolution), Co-Cu peak overlaps deconvoluted

- XFlash® 7 features: High collection angle ideal for low X-ray yield samples - SNR
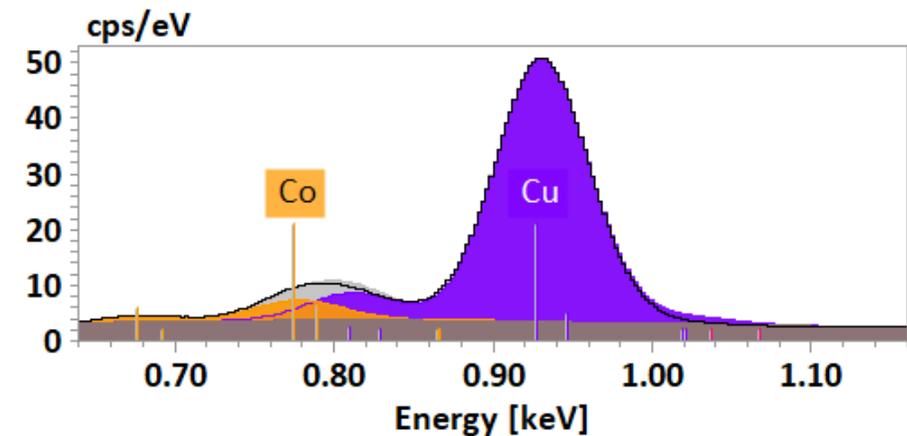
XFlash® 7 – Ensure reliability!

Detector stability is the basis for data acquisition and reliable quantification results regardless of microscope settings and measurement conditions, meaning:
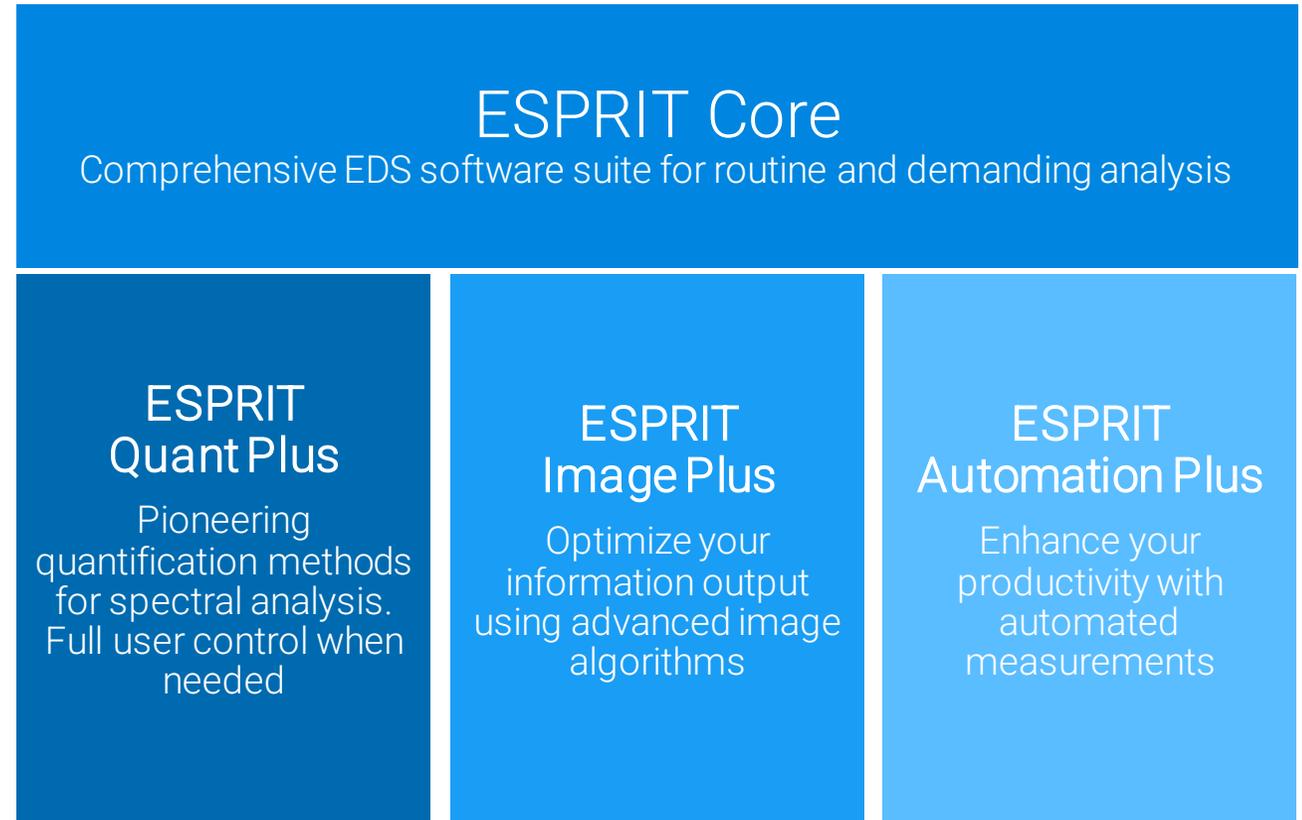
- Save time and maximize system uptime as no frequent detector recalibration is required

- Get highest quality of quantification results in shortest time

- Identify and deconvolute overlapping peaks correctly, independent of throughput and resolution (absolute stable peak position)

- Ensure result integrity with the unique ESPRIT quantification algorithms even at extreme measurement conditions
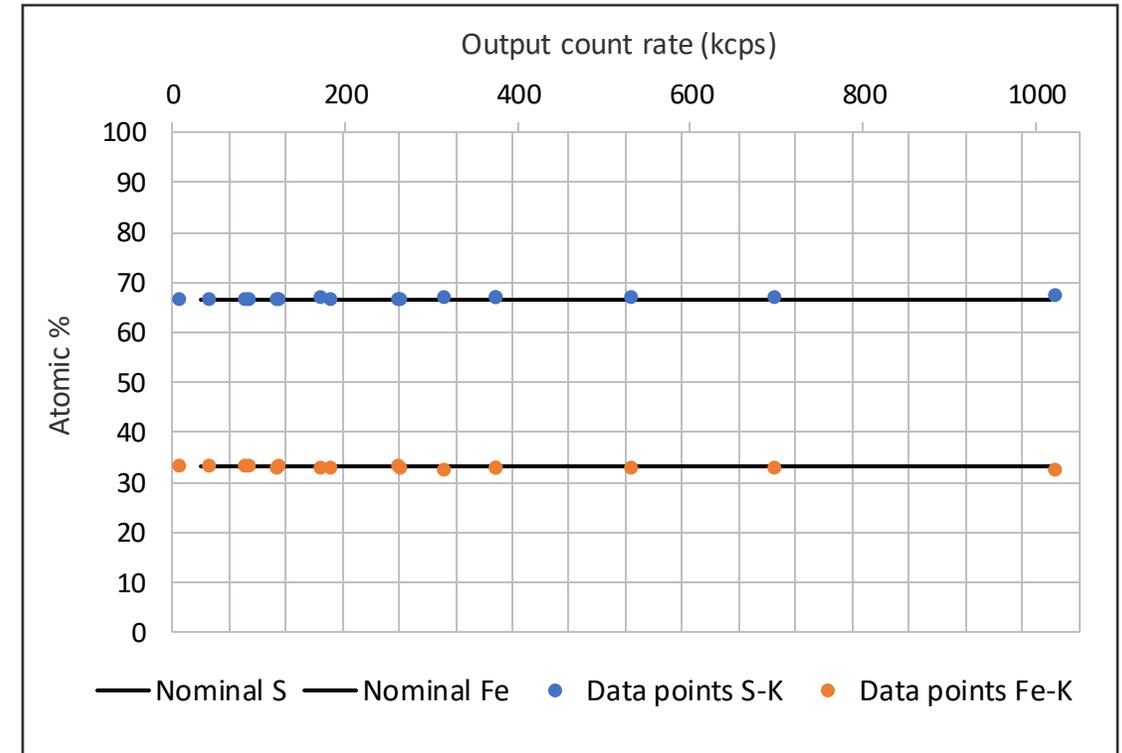
Fe and S quantification results of stoichiometric FeS_2 at different output count rates (OCR)

ESPRIT software suite − New packages

- ESPRIT Core
  - The base package including ESPRIT HyperMap
- ESPRIT Quant Plus
  - Includes all quantification options for SEM and TEM, standardless and standard-based, QLine, QMap.
  - Automated and customized quantification methods
- ESPRIT Image Plus
  - Includes all image processing tools, Drift correction, Stage control, StageMap, ESPRIT LiveMap, etc.
- ESPRIT Automation Plus
  - Jobs, Particle and Time Resolved Measurements

ESPRIT Core
Comprehensive EDS software suite for routine and demanding analysis

ESPRIT Quant Plus
Pioneering quantification methods for spectral analysis. Full user control when needed

ESPRIT Image Plus
Optimize your information output using advanced image algorithms

ESPRIT Automation Plus
Enhance your productivity with automated measurements

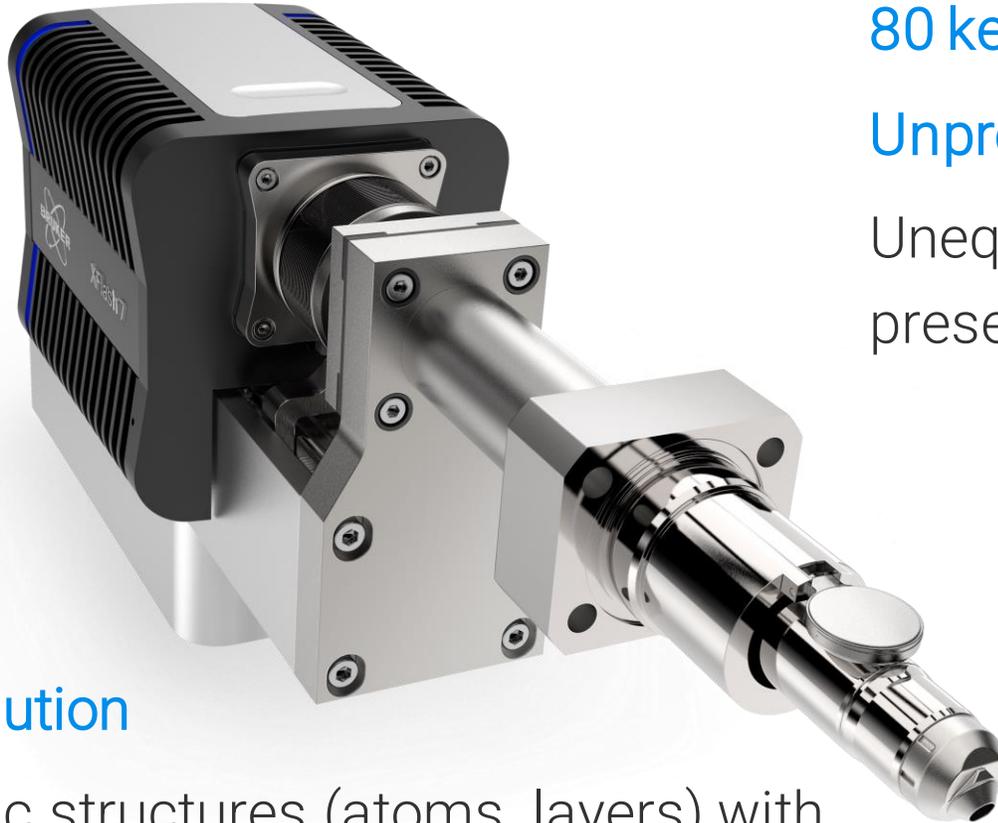# XFlash® 7 – The right angle for better analysis

Fast. Precise. Reliable.

XFlash® 7 - the detector
for SEM and FIB-SEM
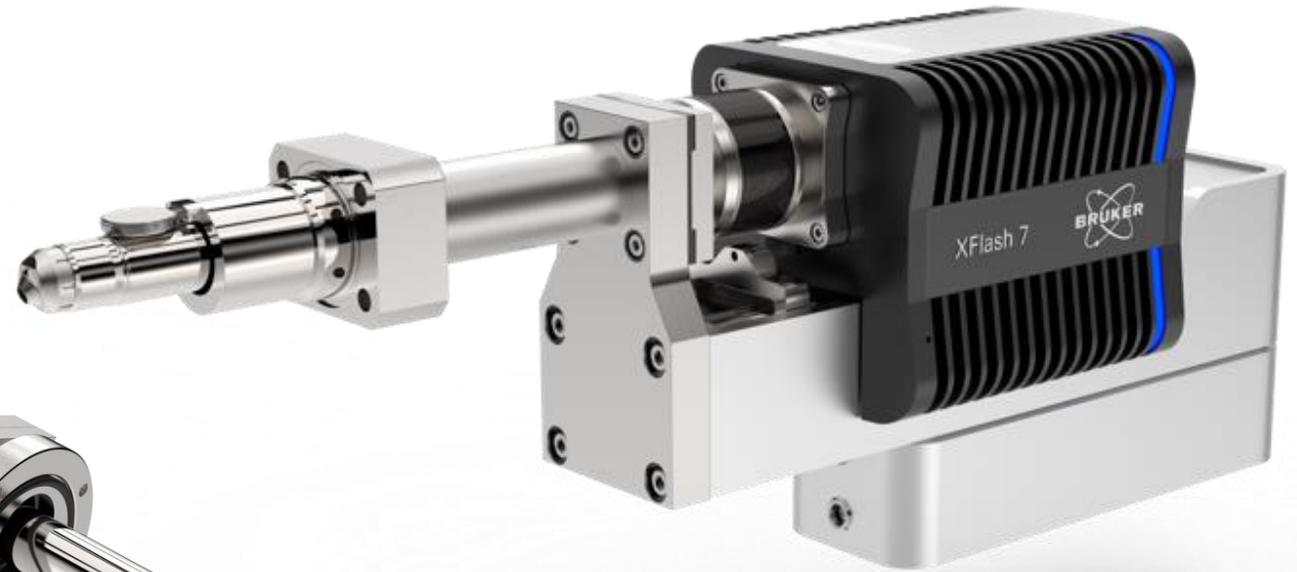
XFlash® 7T - the detector
for TEM and STEM

XFlash® 7T for TEM – Key facts

80 keV

Unprecedented upper energy limit

Unequivocally identify and quantify all present elements

3 TEM-Quantification models

Succeed in TEM, STEM and T-SEM with easy-to-use powerful quantification based on theoretical and experimental Cliff-Lorimer factors as well as Zeta-factor interpolation

1 Å

Stable resolution

Map periodic structures (atoms, layers) with high stability using enhanced drift correction features

XFlash® 7T – Benefits

- Fast acquisition of precise and reliable data thanks to

  - High count rate at minimized absorption and shadowing effects, rarely need to tilt

  - Easy to understand user interface: you see what you do!

  - Comprehensive data mining during and after data acquisition

  - Unequivocal element ID relying on element lines up to 80 kV

  - High spatial resolution with drift correction routines adapted for periodic including atomic structures

  - Fast-moving stable detector stage

  - Minimized mechanical and electromagnetic interference

- In-situ monitoring of processes in transmission with highest spatial resolution using

  - Time resolved data acquisition during in-situ experiments

- Automation of data acquisition and analysis processes using scripting and API options for

 - Generation of specific analysis jobs

  - Batch processing
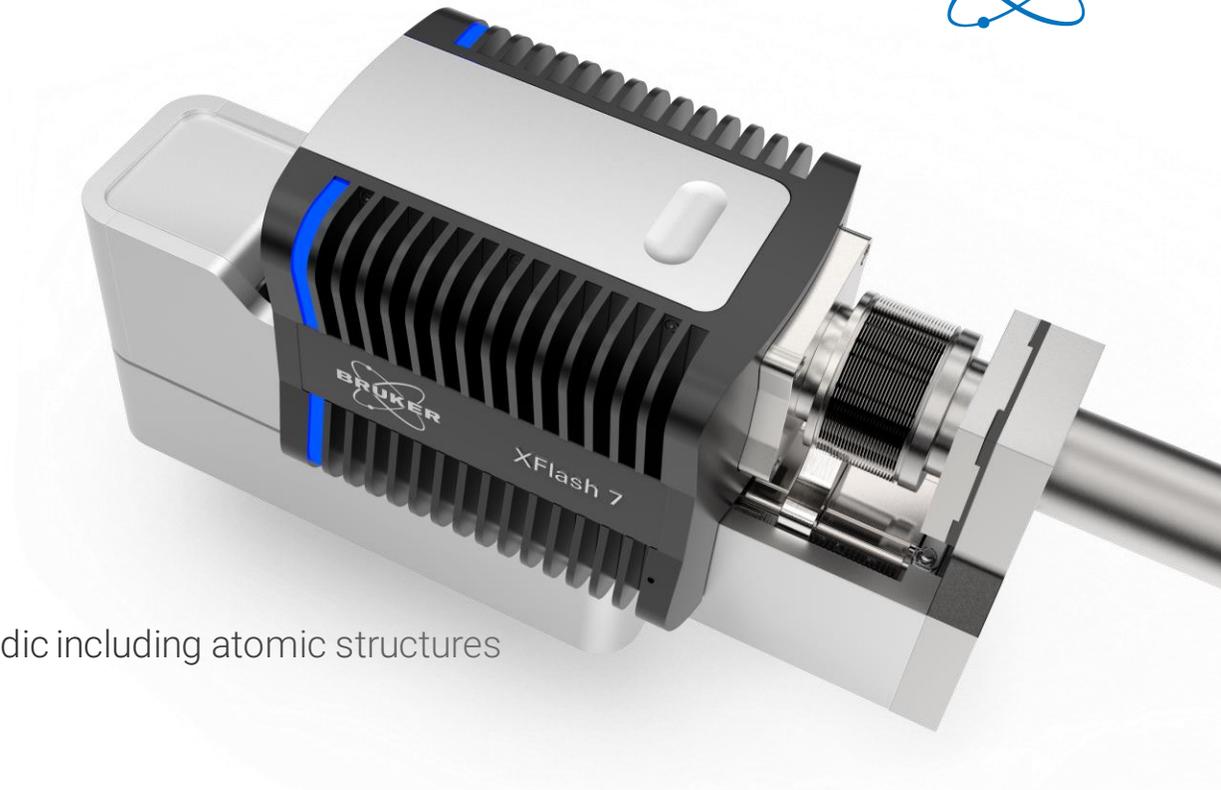
XFlash® 7T – Stable resolution from nm to 1Å

- Slim-line design and geometry optimization for each microscope pole piece type ensure **maximum collection and take-off angle** for fast data acquisition

- Avoiding specimen tilt, absorption, shadowing and system peaks.

- **No mechanical or electromagnetic interference** with high-end TEM performance, even at atomic resolution.

- EDS element mapping in TEM, STEM and SEM (T-SEM) on the **nanoscale with drift correction for periodic features**, such as quantum wells and atom columns.
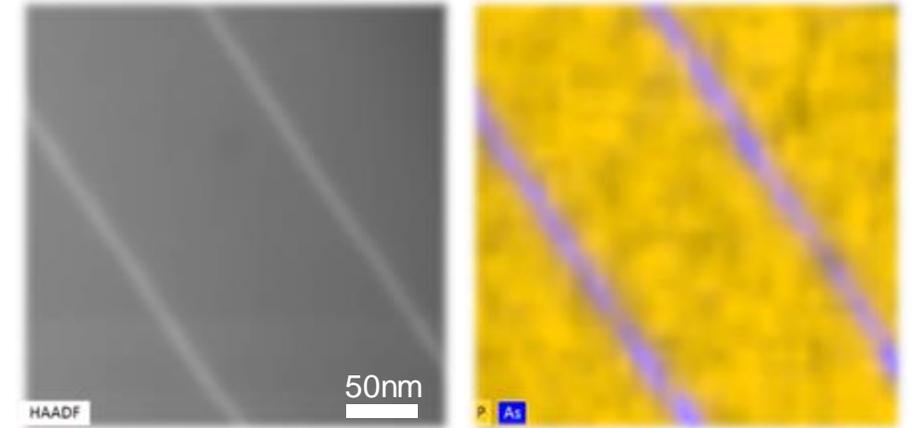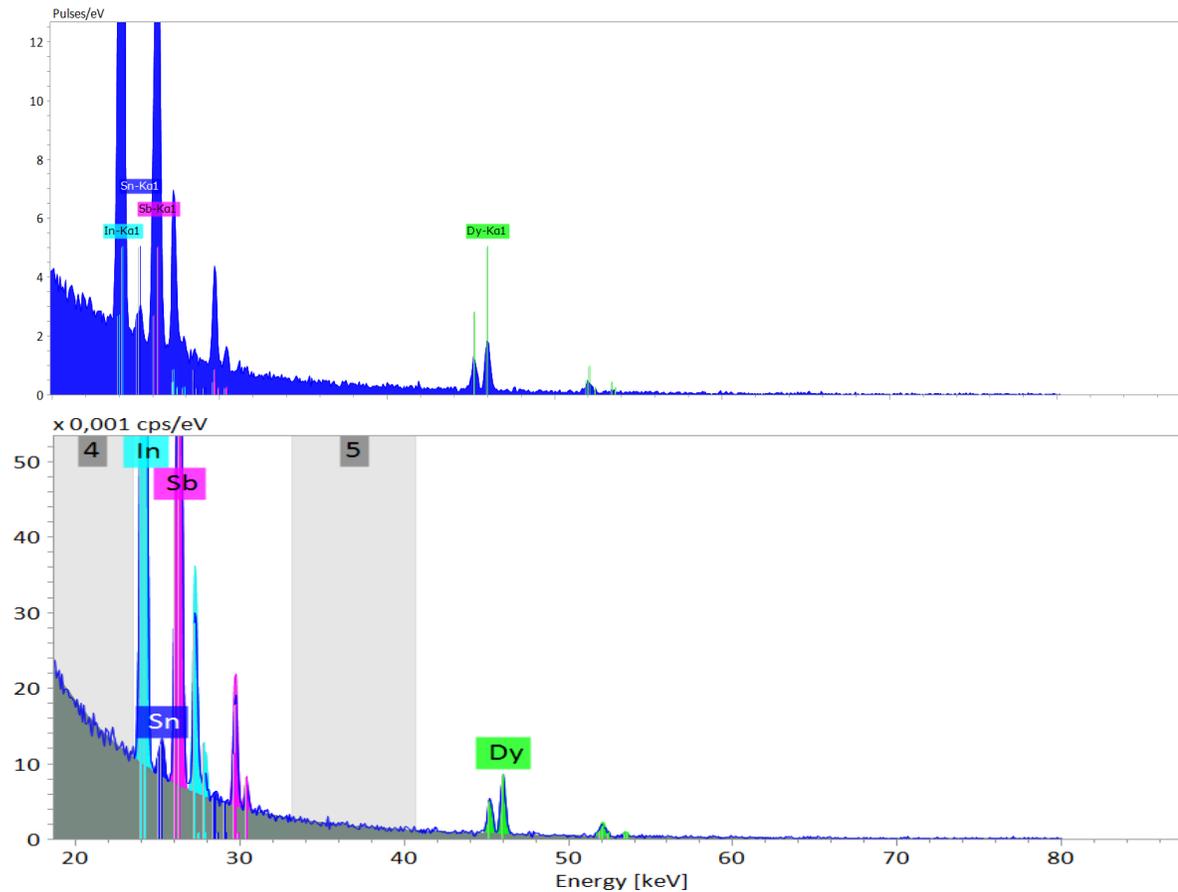

Data courtesy: Nion Co.: III-V quantum wells
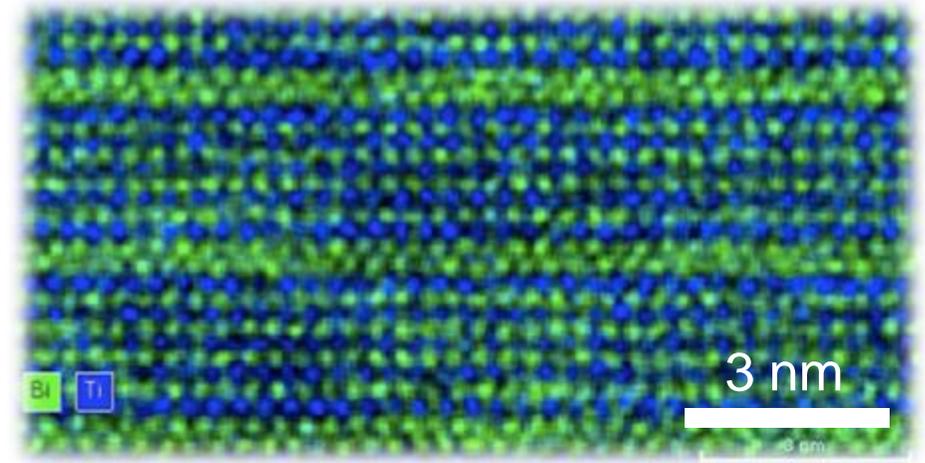
*Data courtesy: L. Keeney et.al, TCD, Dublin; Multiferroic material*

XFlash® 7T – 80 kV element lines for quantification

Example: Dy_2InSbO_7 powder, high and low energy line deconvolution for quantification
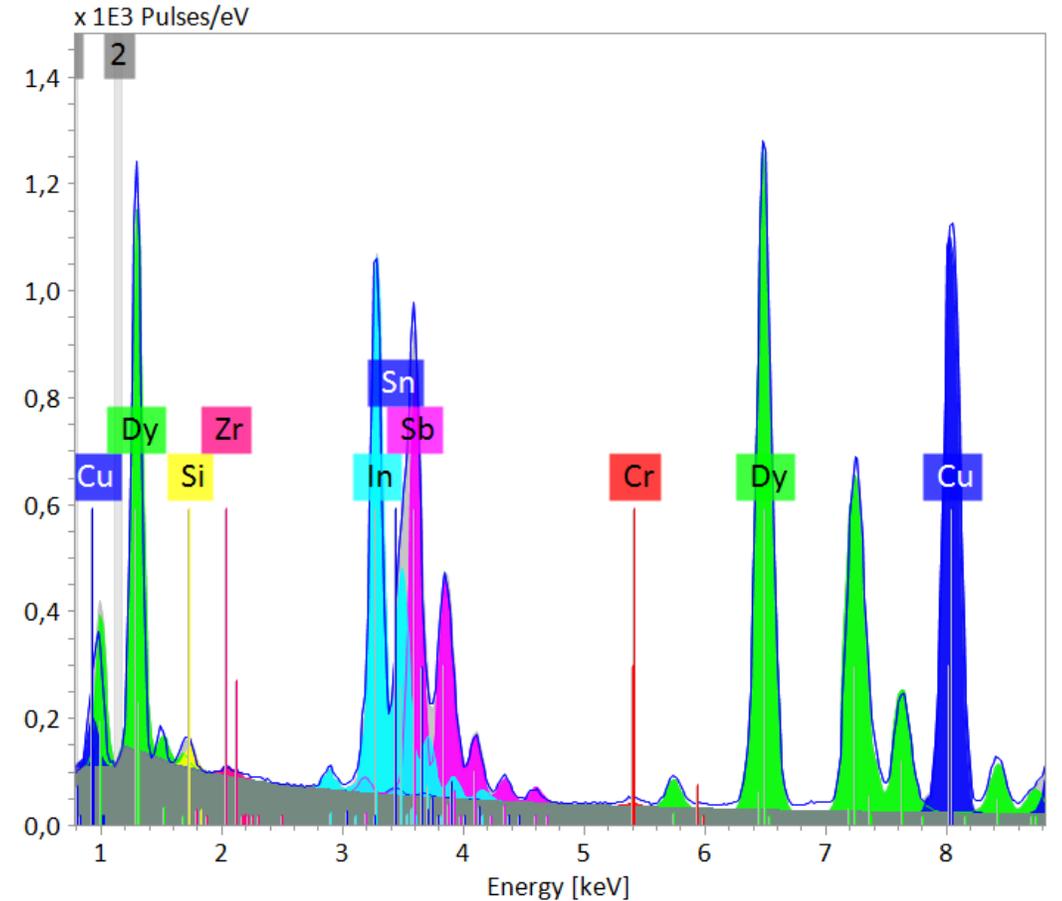
XFlash® 7T – 3 quantification models for TEM, STEM and STEM in SEM (T-SEM): Si-based semiconductors

- **Quantitative EDS in STEM** using the Cliff-Lorimer method allows to distinguish pure nitrogen and titanium nitride in semiconductor nanostructures.
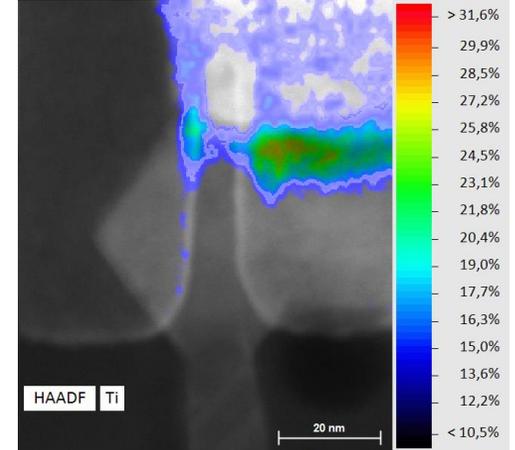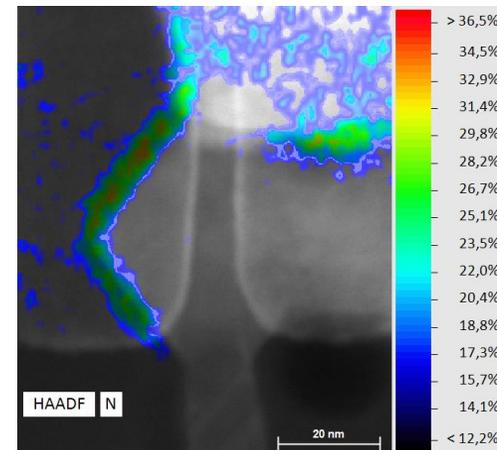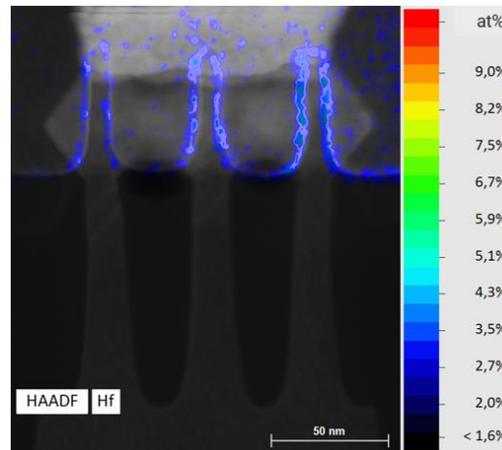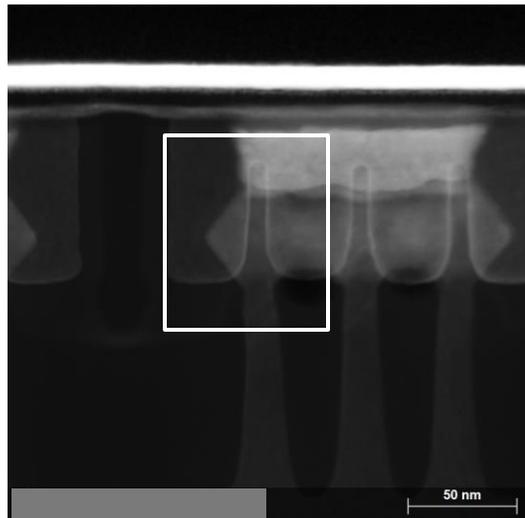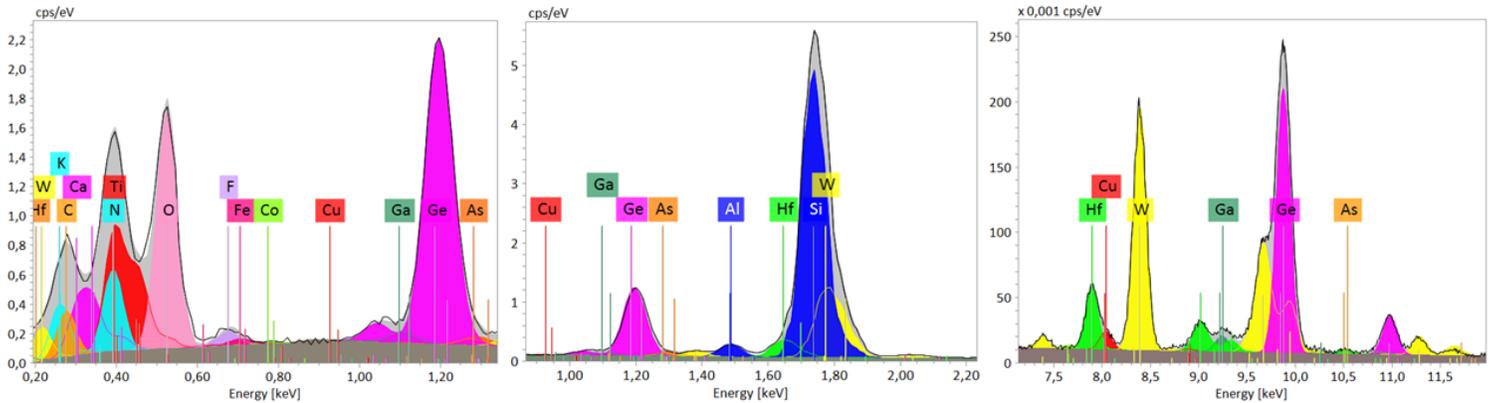
Data courtesy: ACE

ESPRIT software suite – Dedicated to solving challenging tasks

- ESPRIT TEM Performance
  - Basics for TEM including Cliff Lorimer Quantification
- ESPRIT STEM Performance
  - Basic analysis tool for STEM including Cliff-Lorimer Quantification, ESPRIT HyperMap and Drift Correction
- ESPRIT Quant Plus STEM > Advanced Quant Package
  - Enables quantitative mapping and includes all additional quantification routines for the analysis of bulk and electron transparent specimens
- ESPRIT TRM Automation without stage control
  - Time Resolved Measurement and batch processing,

- More ESPRIT features and SEM packages if suitable for image and particle analysis, stage control etc.

ESPRIT Performance for TEM and STEM/T-SEM

Comprehensive EDS software suite for daily tasks and much more

| ESPRIT Quant Plus STEM	ESPRIT TRM Automation	ESPRIT Image Plus / Automation Plus
Pioneering quantification methods for spectral analysis. Full user control when needed	Time resolved measurements w/wo stage movement Automate routine tasks, let ESPRIT do the job	Advanced algorithms for automation of data acquisition and optimizing information output

XFlash® 7T – ESPRIT Software for TEM, STEM and STEM in SEM

- Flexible and easy-to-use ESPRIT software package, also for in-situ experiments

- Complete data mining on your own terms with individual off-line analysis options or LAN access

- ESPRIT SW for quantitative TEM EDS offering:

  - Automatic and semi-automatic quantification routines for each user level with default and individual settings

  - Coverage of all possible scenarios with different quantification routines based on theoretical and experimental Cliff-Lorimer factors, as well as Zeta factors and the interpolation of missing Zeta-factors

  - Unambiguous results thanks to TEM-specific quantification based on high energy element lines (> 40 keV)

  - Accommodation of diverse specimen thickness with a choice of background models: a physical one for bulk and a physical one for thin lamellae as well as a mathematical model

  - Absorption correction
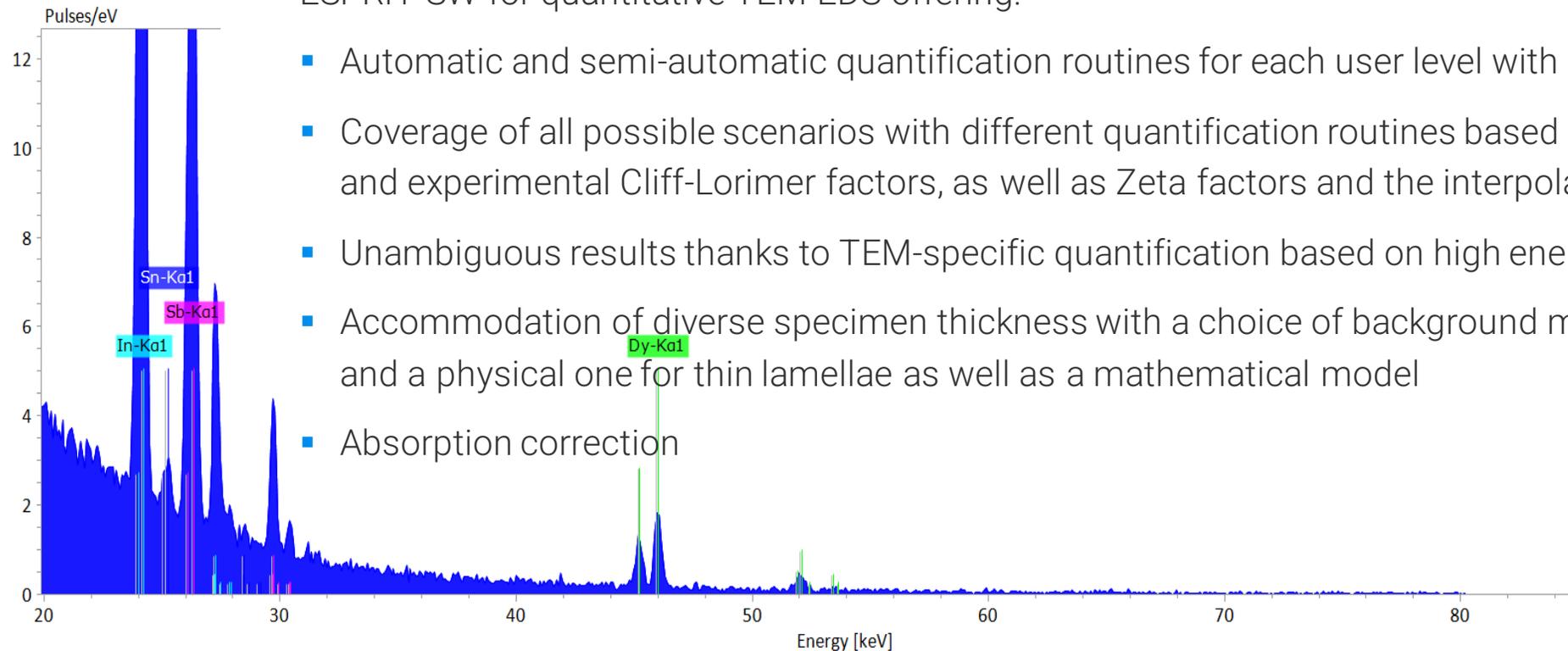
XFlash® 7T – 3 quantification models for TEM, STEM and STEM in SEM (T-SEM): Light emitting III-V diodes

- Easy-to-use powerful quantification procedures based on theoretical and experimental Cliff-Lorimer factors as well as Zeta-factor interpolation ensure complete data mining for semiconductor specimens in FIB and SEM.
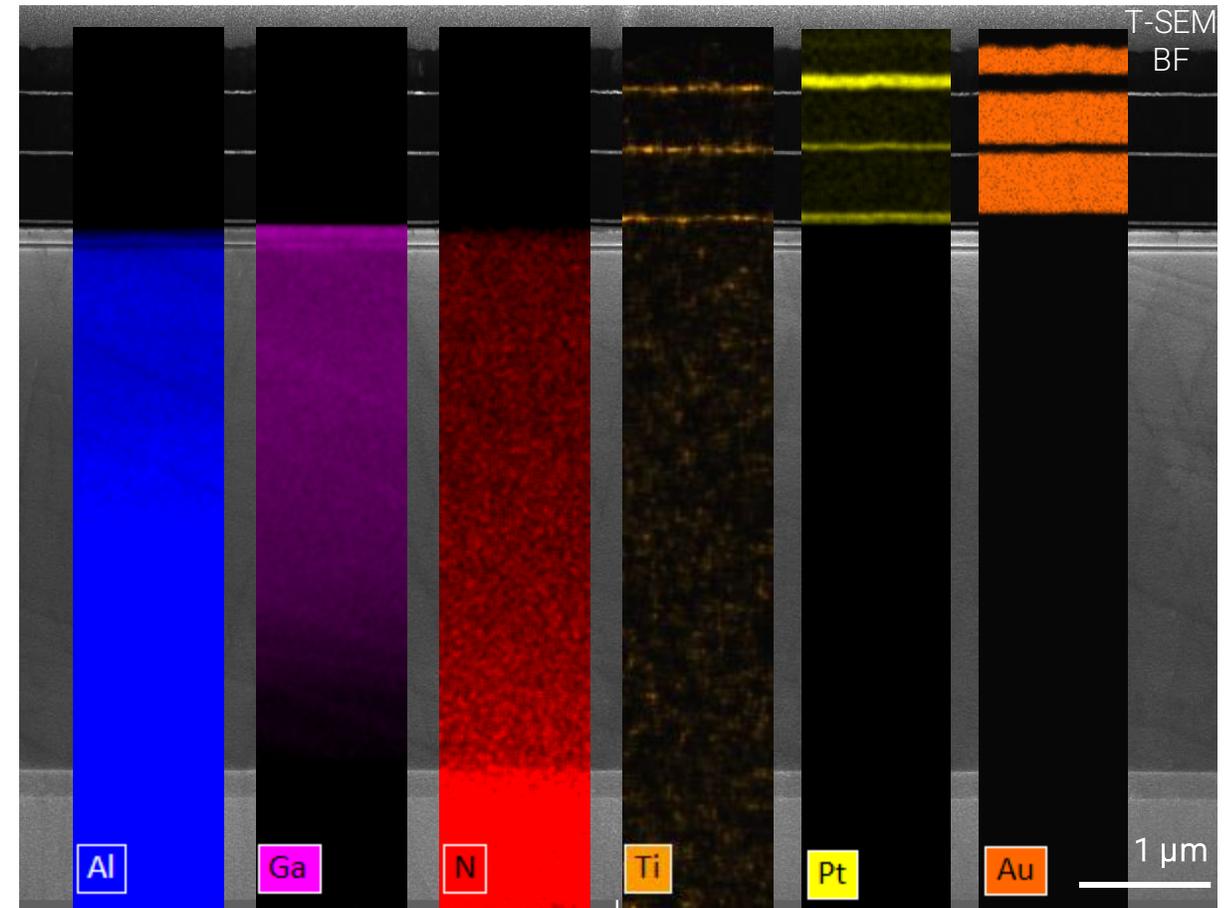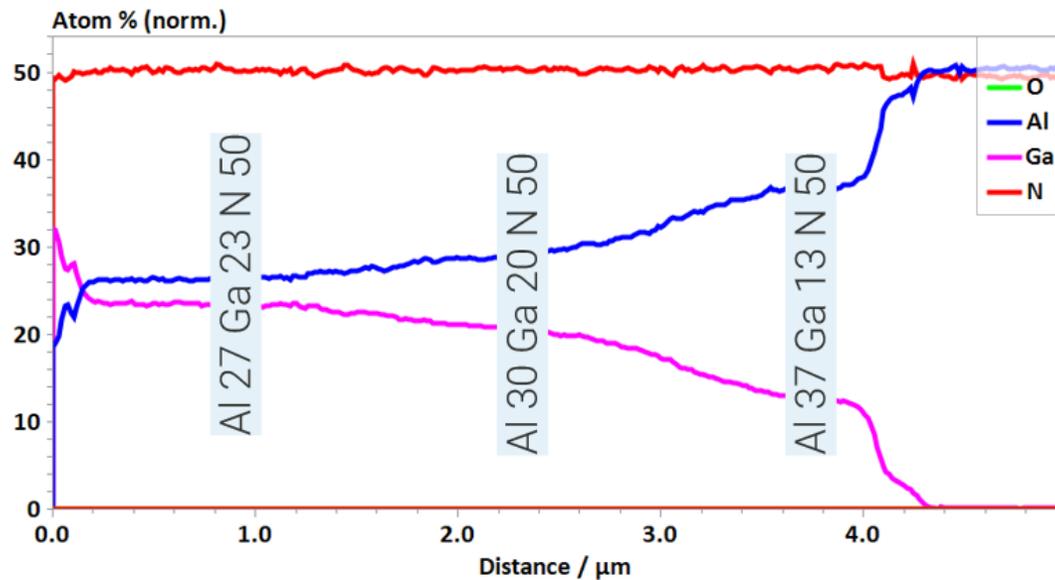
Light emitting diode structures with Ga grading
Sample courtesy: FBH, Berlin

XFlash® 7T – 3 quantification models for TEM, STEM and STEM in SEM (T-SEM): Light emitting III-V diodes
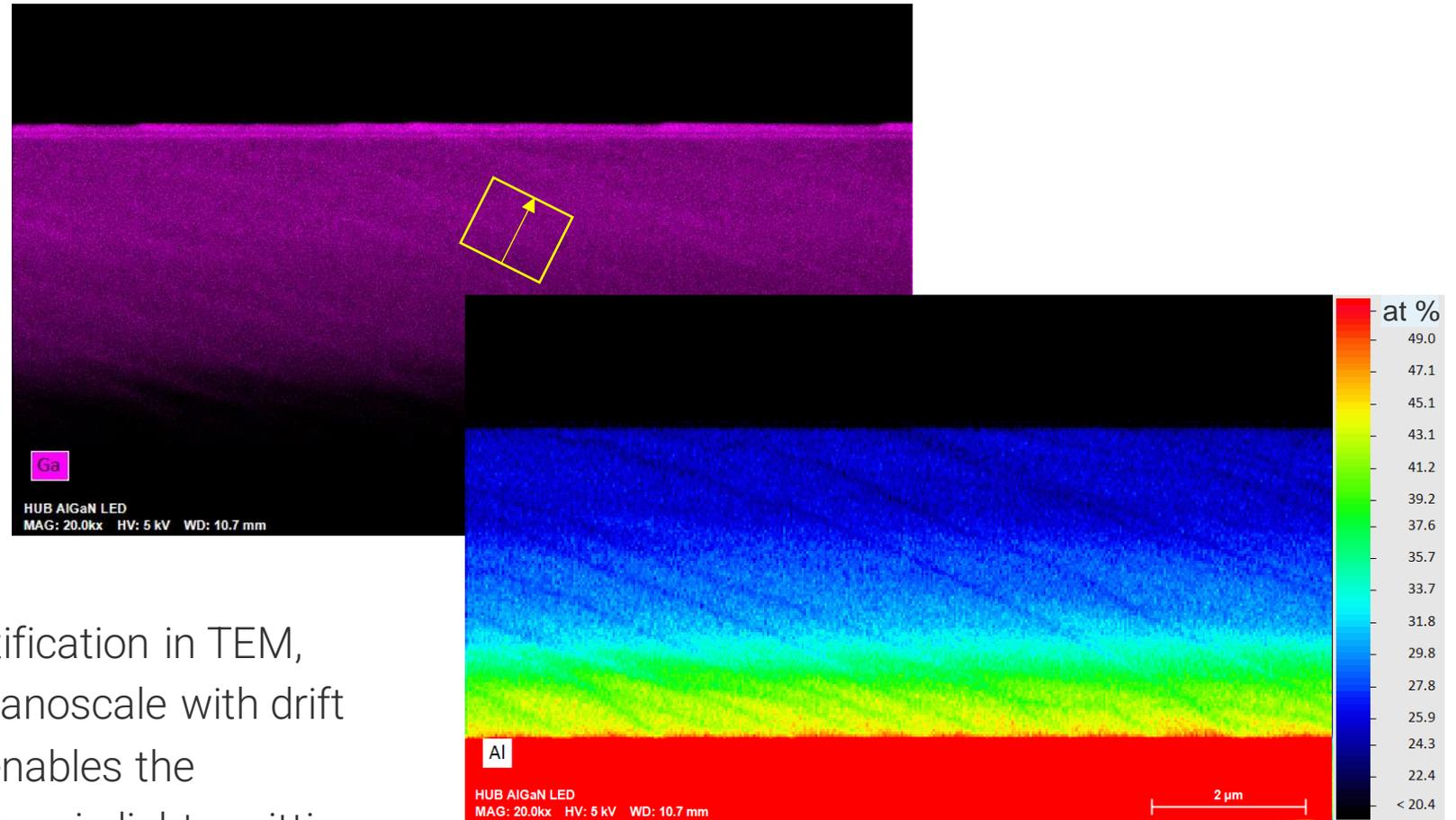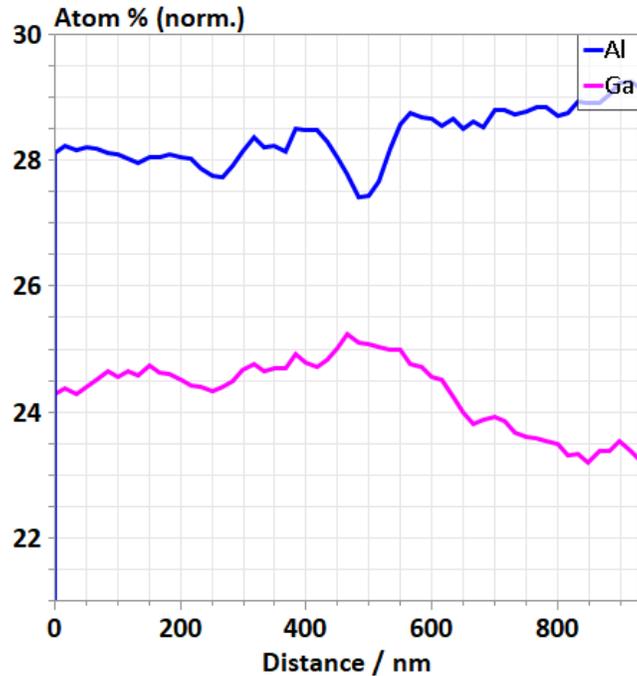

- EDS element mapping and quantification in TEM, STEM and SEM (T-SEM) on the nanoscale with drift correction for periodic features enables the quantification of Al depleted regions in light emitting diode specimens.

Light emitting diode structures with Ga grading
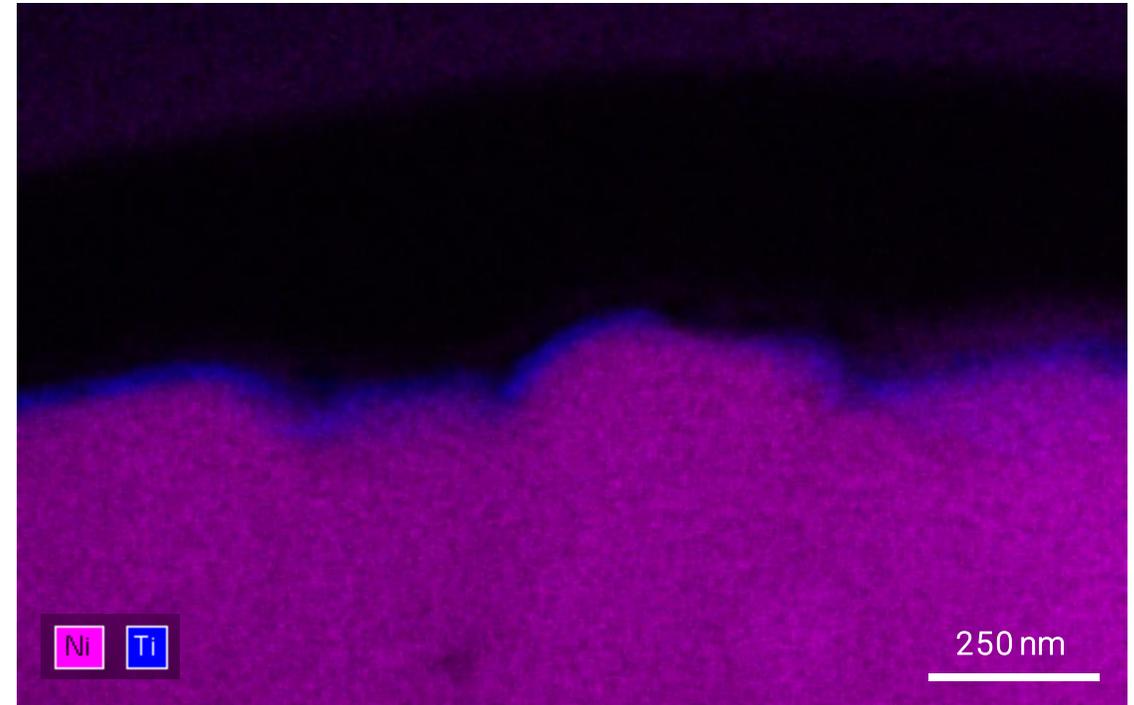Sample courtesy: FBH, Berlin

XFlash® 7T – 3 quantification models for TEM, STEM and STEM in SEM (T-SEM): Li-ion battery cathode particle

- Analysis of a coated Li-ion battery NCM cathode particle ($LiNi_xMn_yCo_zO_2$):
  the homogeneity of the Ti coating is important for capacitance retention of batteries
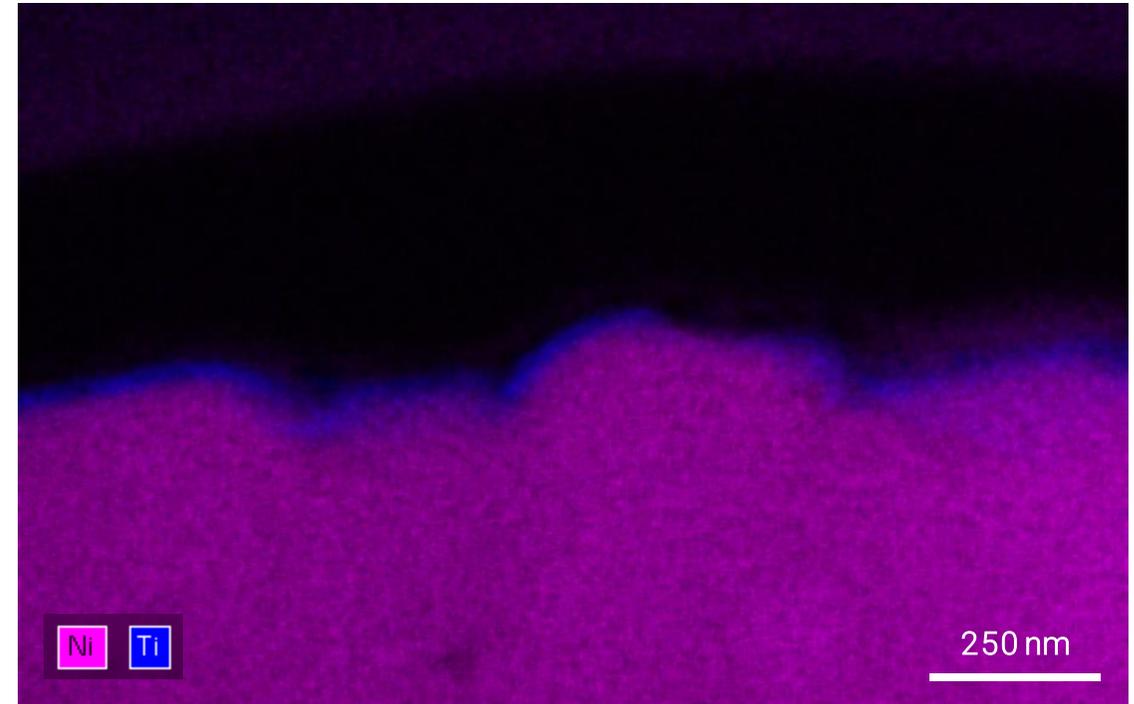
250 nm

250 nm

Ni Ti
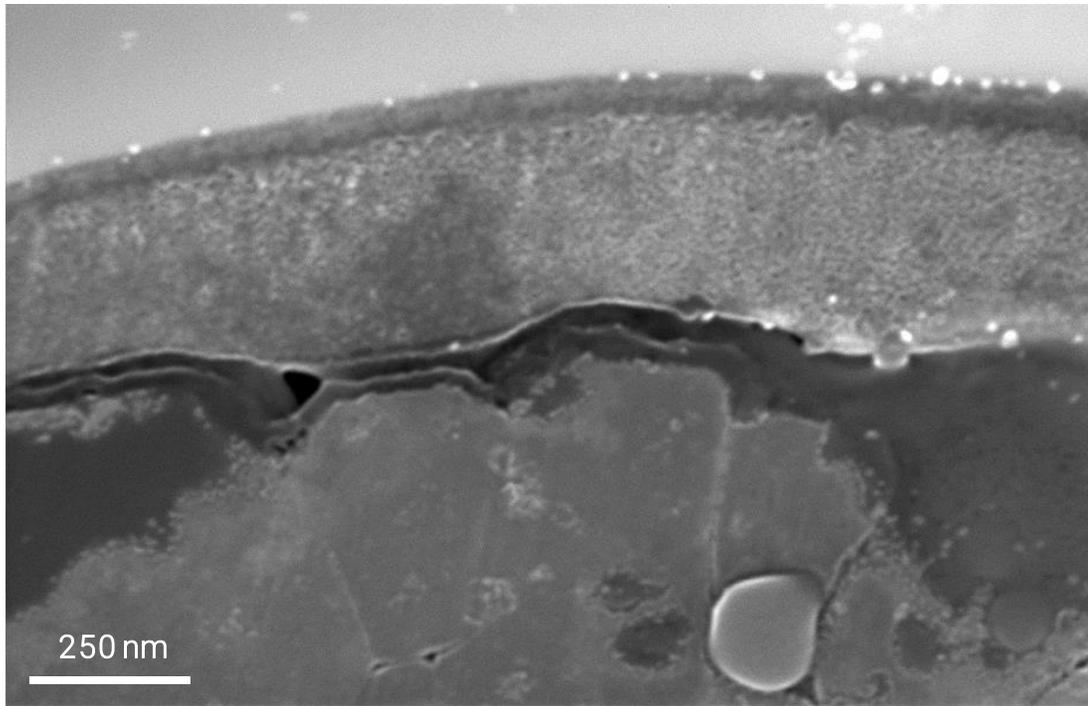
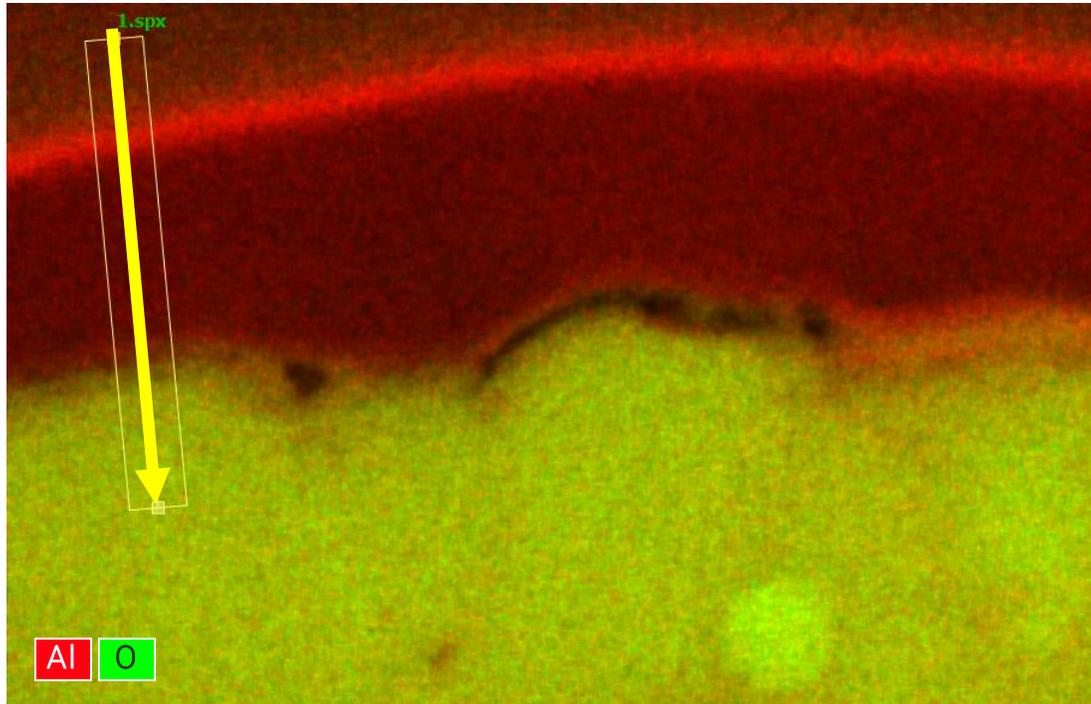In-lens image, mixed contrast

Element distribution maps: Ti coating, Ni: NCM particle

Image and sample courtesy: M. Malaki, Sh. Ahmed; Material Science Center, Faculty of Physics, Philipps University Marburg

XFlash® 7T – 3 quantification models for TEM, STEM and STEM in SEM (T-SEM): Li-ion battery cathode particle

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XFlash® 7T – 3 quantification models for TEM, STEM and STEM in SEM (T-SEM): Li-ion battery cathode particle

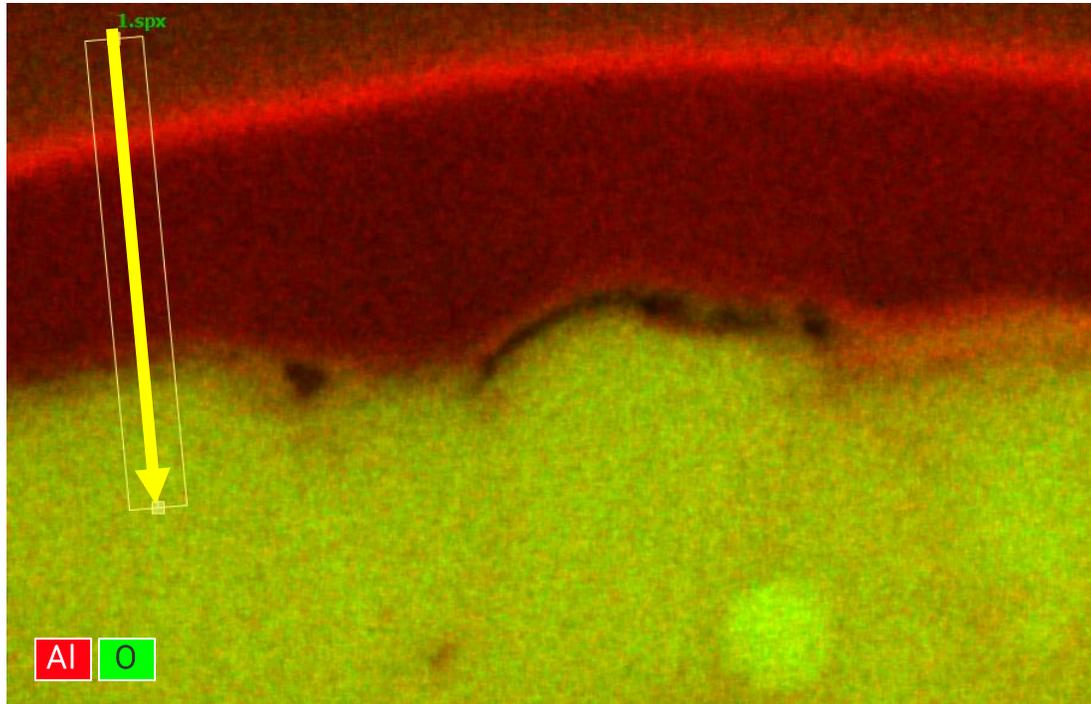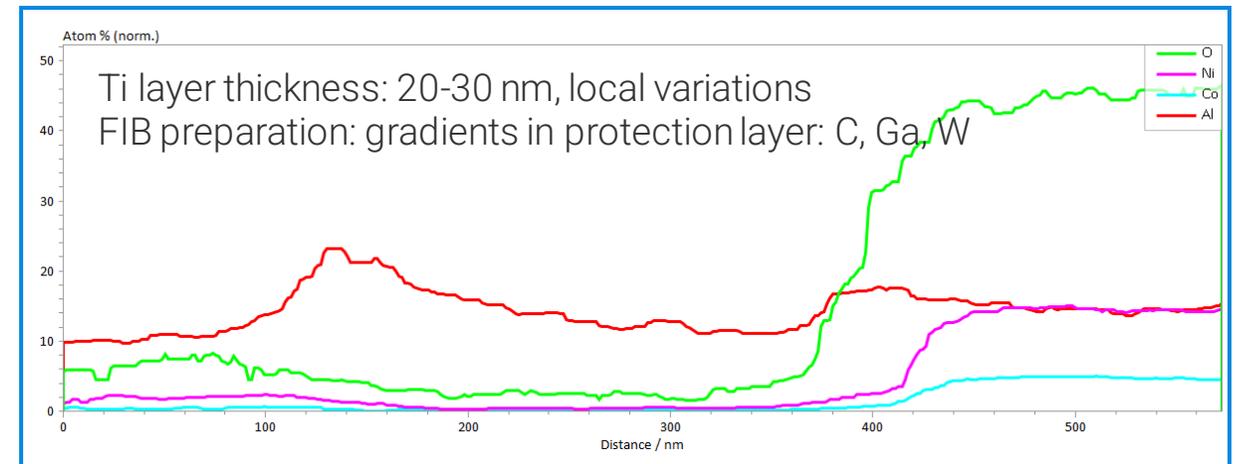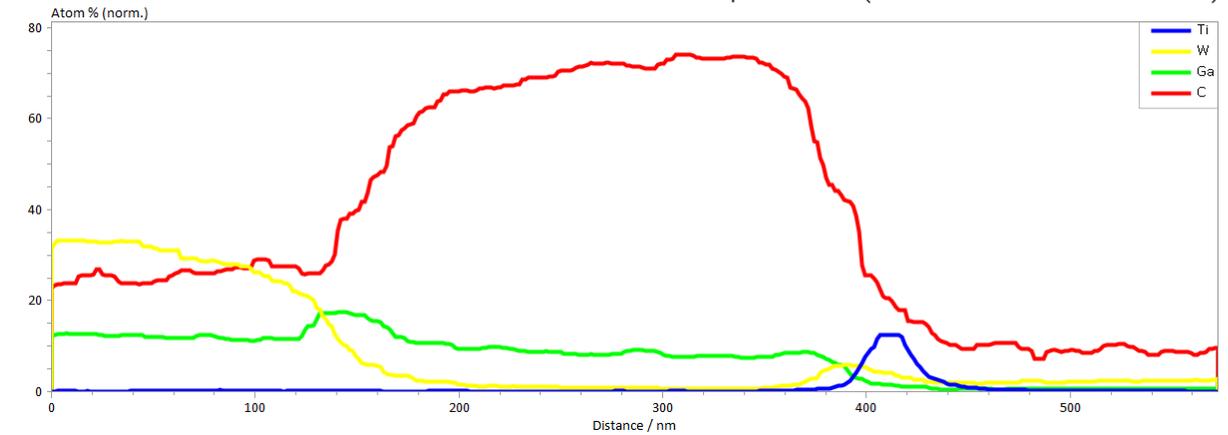- Ti layer thickness – quantitative composition line profiles

Quantitative line profiles (Cliff-Lorimer method)

Ti layer thickness: 20-30 nm, local variations
FIB preparation: gradients in protection layer: C, Ga, W

Image and sample courtesy: M. Malaki, Sh. Ahmed; Material Science Center, Faculty of Physics, Philipps University Marburg
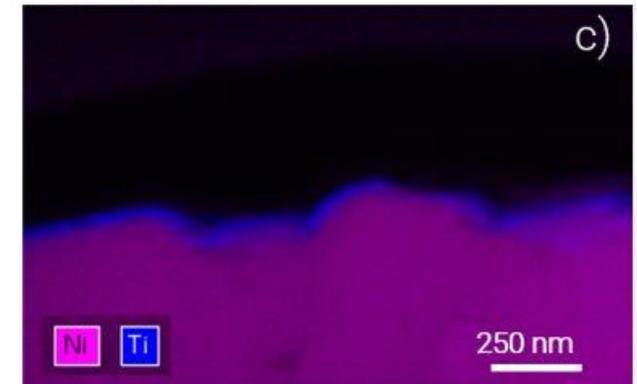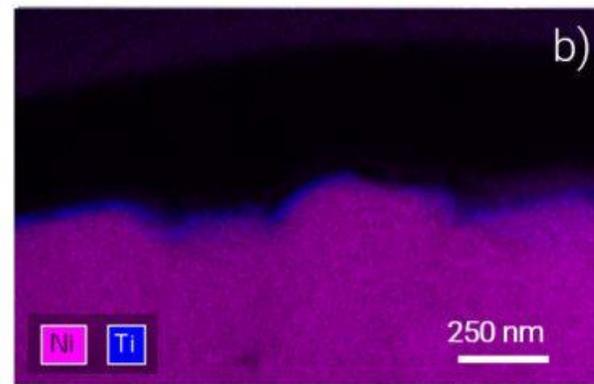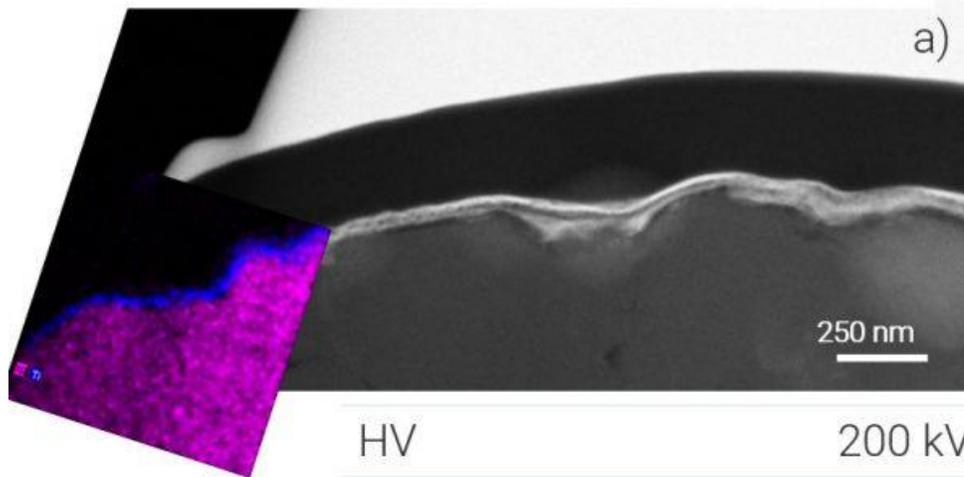
XFlash® 7T – 3 quantification models for TEM, STEM and STEM in SEM (T-SEM): Li-ion battery cathode particle

- Comparison of the same Ti-coated NCM Li-ion battery particle in cross-section, measured using

a) HAADF image and S(T)EM EDS
STEM @200 kV with 60 mm² EDS

b) conventional SEM EDS
SEM @20kV with 60 mm² EDS

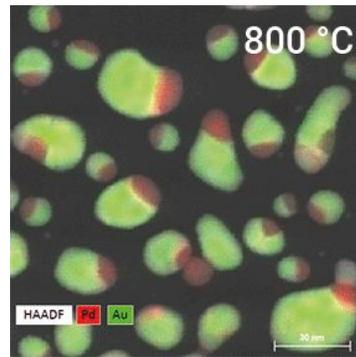c) annular SEM EDS (FlatQUAD)
SEM@20kV with 60 mm² FlatQUAD

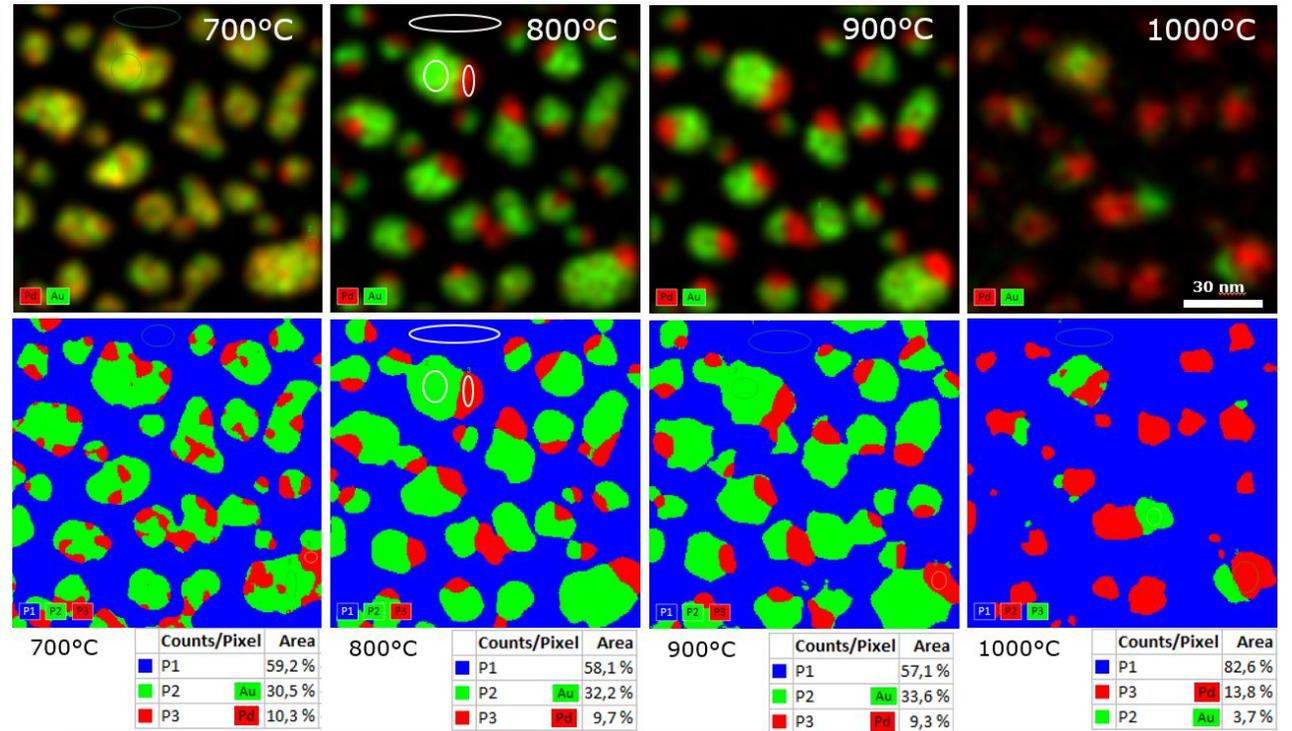|			
HV	200 kV	20 kV	20 kV
Probe current	0.2 nA	2 nA	2 nA
Measurement time	8 min	34 min	34 min
Input count rate	~1 kcps	~30 kcps	~460kcps

Image and sample courtesy: M. Malaki, Sh. Ahmed; Material Science Center, Faculty of Physics, Philipps University Marburg

XFlash® 7T – TRM* time resolved data acquisition for in-situ analysis in STEM

- EDS for high temperatures and other in-situ experiments producing data with temporal resolution, for example during biasing, mechanical manipulation, heating etc.

- Example: mapping at elevated temperatures

STEM at 200 kV

Holder: 700°C - 1000°C

monitoring the evolution of phases and surface coverage for mixed nanoparticles


J. T. van Omme et al., Ultramicroscopy, 192 (2018) 14–20

*TRM= time resolve measurement

XFlash® 7T – TRM* time resolved data acquisition for in-situ analysis in SEM: T-SEM

- EDS for high temperatures and other in-situ experiments producing data with temporal resolution, for example during biasing, mechanical manipulation, heating etc.

- Example: mapping at elevated temperatures, snapshot

SEM at 3kV, holder at 800 °C

Sample: $NiAl_2O_4$ on SiC-film
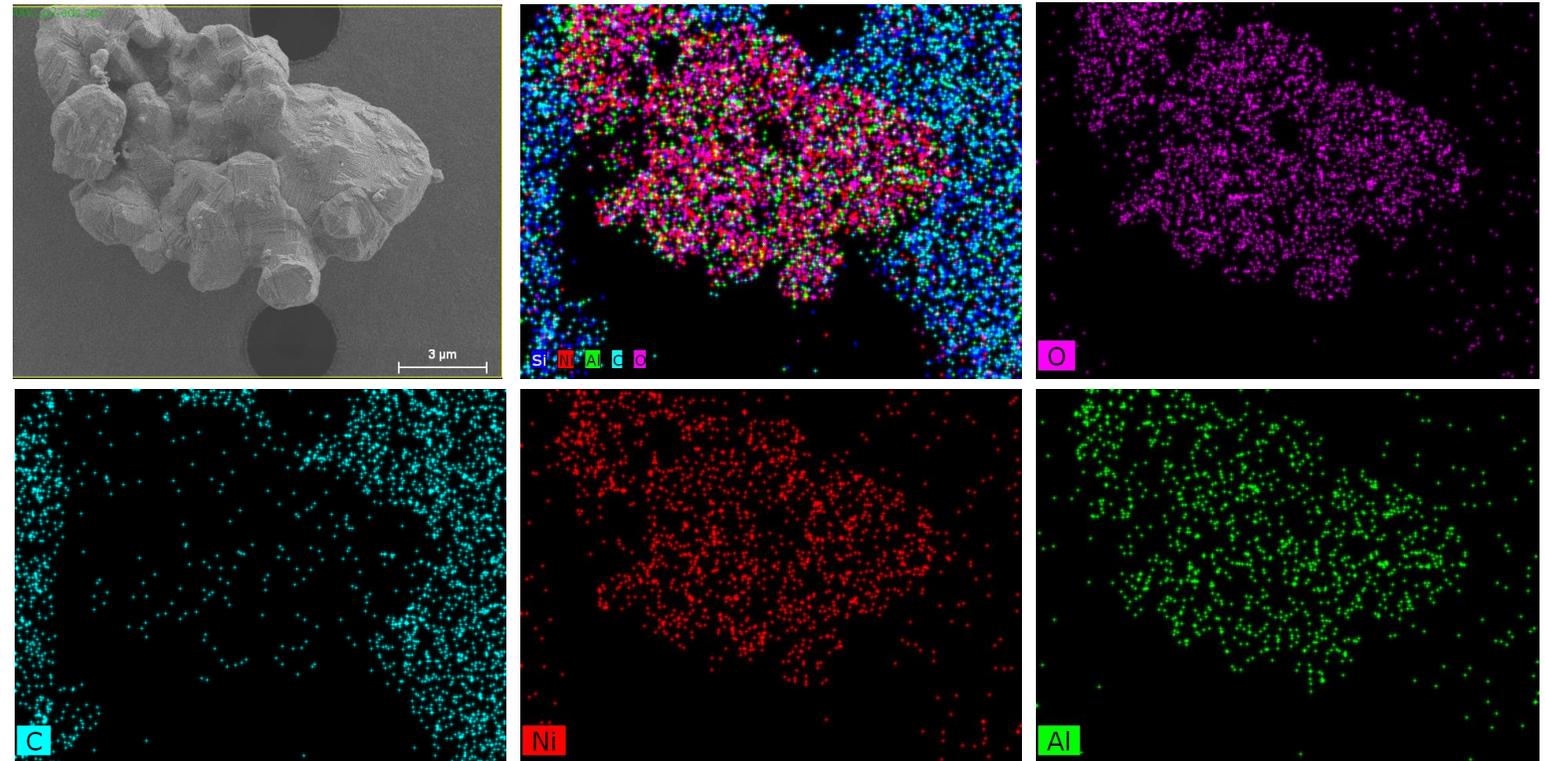
Data courtesy: J. Howe, University of Toronto
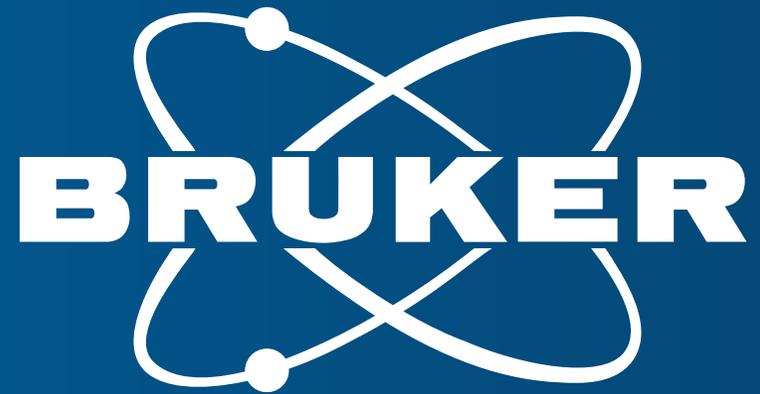
*TRM= time resolve measurement

For more information, please visit

www.bruker.com/XFlash7

or contact your local sales representative or

info.bna@bruker.com

Innovation with Integrity