SIGRAY

AttoMap™-200

X-RAY ANALYTICAL MICROSCOPE WITH SYNCHROTRON CAPABILITIES

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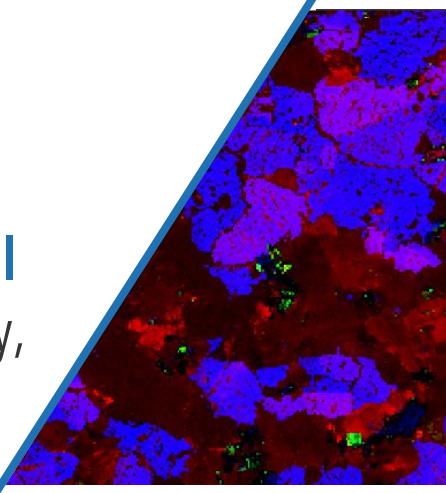
Biological application: Hyperaccumulating seedling with elements of interest of K (Blue), Cl (Green), S (Red) shown and trace accumulation of Ni, Mn in roots detected
Sample provided by Dr. Antony van der Ent and Dr. Peter Erskine, The University of Queensland, Australia



High Resolution Sub-PPM Chemical Mapping for Geology, Biology, Forensics & Materials Research ... Within 1 Second

AttoMap Advantages at a Glance

» Resolution and sensitivity of LA-ICP-MS at **>100X throughput** of µXRF

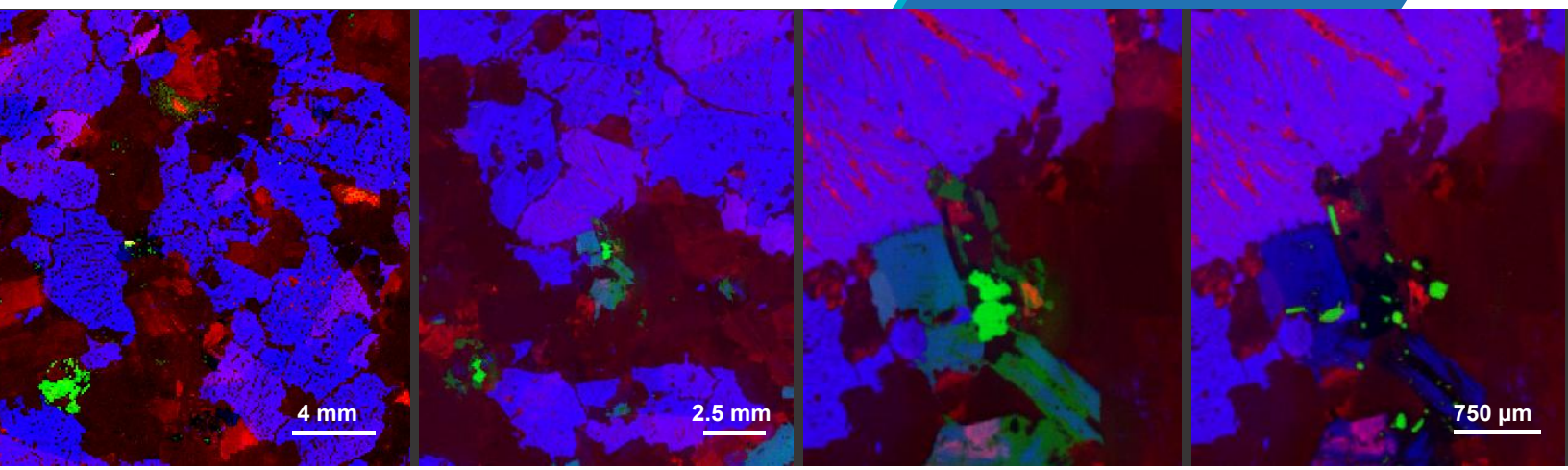
» **Sub-femtogram** ($<10^{-15}$g) sensitivity measurements within 100s (sub-ppm in <1s)

» Access to **multiple x-ray spectra** generated by x-ray target materials and focused with high efficiency by matching x-ray optics

» **Modular system design** with correlative 2D x-ray microscope upgrade included

* Throughput compared at same resolution and sensitivity to leading commercial microXRF systems

Elemental mapping of a geological quartz sample at increasing resolutions, showing K (Blue), Zn (Red), Co (Green), and P (Green in last image) inclusions.



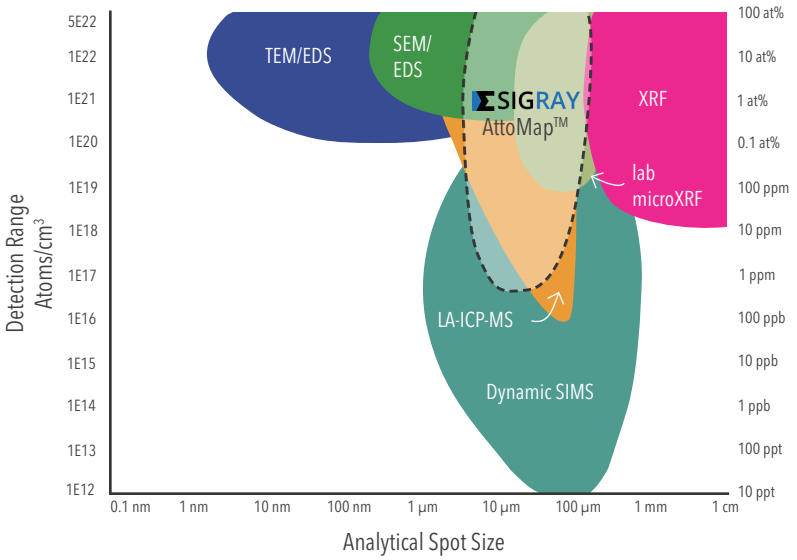
Bring Synchrotron XRF Capabilities to Your Lab

Conduct Ground-breaking Research without Needing to Apply for Beamtime

Sigray's AttoMap™ microanalytical system provides a breakthrough in lab-based microXRF performance, bringing synchrotron capabilities to individual laboratories. The AttoMap™ relies on several major innovations, including Sigray's high brightness multi-target x-ray source and high efficiency x-ray optics. The instrument provides fast, non-destructive chemical mapping at single digit microns resolution (e.g. 3-4 µm) - with detectability of nanoparticles down to 50-100 nm, relative sensitivities of sub-ppm, and absolute detection levels of sub-femtogram.

What is MicroXRF?

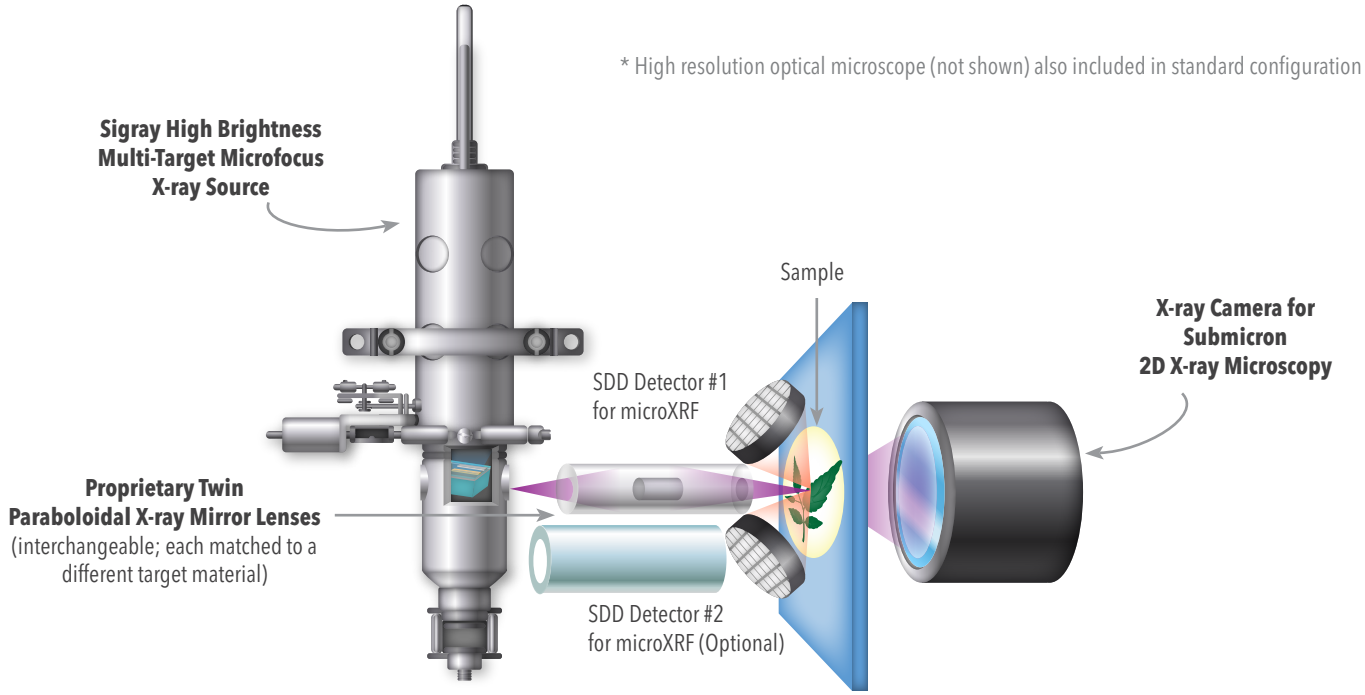
Micro x-ray fluorescence (microXRF) is a powerful spatially-resolved elemental mapping and chemical microanalysis technique originally developed and advanced at x-ray synchrotron sources. In response to x-ray excitation, a sample will produce characteristic x-rays that can be analyzed to determine composition. Unlike other techniques, microXRF provides analysis of multiple elements simultaneously and can be used to reveal buried features without requiring sample preparation.



A Powerful New Method: The Sigray AttoMap™ is a step change from existing laboratory microXRF capabilities in resolution and detection sensitivity performance, at levels comparable to LA-ICP-MS and with advantages for low atomic number elements and maintaining high sensitivity at small spot sizes.

Enabled by Patented X-ray Technology

Three core new approaches enable the AttoMap™'s unprecented performance: 1) x-ray source featuring an innovative multi-material target, 2) proprietary high efficiency x-ray mirror lens, and 3) innovative detector geometry.



How will Sigray Help Meet Your Research Needs?

Application	AttoMap™ Advantage over Other Approaches
Biology	Ability to analyze multi-elemental nanoparticles and detect nanoparticles down to 50 nm Trace elemental distribution mapping at sub-cellular resolution for metallomics; complementary to MALDI Chemical mapping on hydrated samples with correlative mapping using optical and x-ray microscopy
Geology	Correlative x-ray absorption imaging (2D microscopy) and chemical analysis (microXRF) Mapping of mineralogy for tailings liberation analysis in mining and of drill cores for O&G exploration Geochronology, rare earth elements for geochronology and *in situ* analysis
Pharmaceutical	Distribution of active ingredients to assess bioavailability of formulations in R&D and for quality control
Semiconductor	Non-destructive analysis of buried material composition and contamination Measurement of thickness of thin layers (detection sensitivity down to single atomic layers)
Materials Science	Highest resolution and sensitivity for advanced materials applications Complementary to alternative techniques such as LA-ICP-MS and SEM-EDS Ability to accomodate large sample sizes and large working distance for analysis of samples in situ

AttoMap Technology Overview

1) Multi-Target Microfocus Source

High Brightness with Selection of X-ray Energies

The AttoMap uses Sigray's high brightness microfocus source featuring an innovative x-ray target comprised of multiple materials in thermal contact with a diamond substrate. Each target material is software selectable, so that multiple x-ray spectra are easily accessible within the system. This is critical to microXRF for which performance is heavily dependent on the exciting x-ray energy (see table to the right).

The target is designed to combine the advantages of:

- Rapid thermal dissipation, provided by high degree of contact between the target materials and diamond (thermal conductivity: 22 W/cm^2) to enable highly localized thermal gradients so that the target remains cool under high power loading, with the
- Linear accumulation of x-rays to enable near-zero take-off angles

The combination of the thermal advantages and linear accumulation result in an ultrahigh brightness x-ray source ideal for rapid microXRF.

2) Proprietary Paraboloidal X-ray Optics

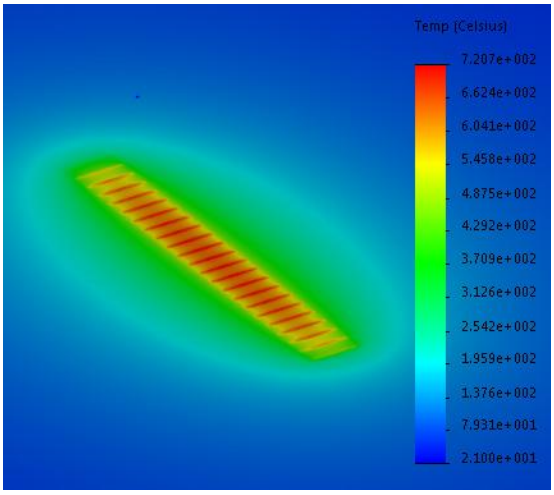
Optimized for Each X-ray Target Material

Sigray's twin paraboloidal x-ray mirror lens provides tremendous benefits over the standard polycapillary x-ray optic employed by existing microXRF systems. The optics are fabricated by a high precision advanced manufacturing process that achieves minimal slope errors and a reflecting surface smoothness on the order of single digit angstroms. Each optic provides high resolution and achromatic focusing (all x-ray energies produced by the source are focused into the same spot size) for at large working distances. For each x-ray target material, a matching x-ray optic is provided so that efficiency is optimized for the specific spectra produced by the target material.

3) Innovative Detector Geometry

Correlative & Up to 3-4X Collection Angle

AttoMap features multiple detectors, with a SDD microXRF detectors for compositional analysis and an x-ray camera for submicron structural imaging, empowering correlative analysis. The large solid angle of collection of the microXRF x-ray detectors in the Sigray setup is uniquely made possible by use of the twin paraboloidal x-ray mirror lens, which provides the long working distance and compact form factor needed for optimized placement of the detectors.



Thermal Benefits of the FAAST Source

Finite element analysis of one configuration of the FAAST source. The target design provides thermal advantages to achieve dramatically higher power loading in comparison to the extended metal targets used in conventional microfocus x-ray sources.

	2.7 (Rh L)	5.4 (Cr K)	8 (Cu K)	9.4 (Pt L)	17.4 (Mo K)
B	1.5				
N	19	2.3			
F	119	16	4.7		
Na	504	70	22	13	
Al	1,627	240	77	47	7
P	4,114	656	215	135	21
S	6,155	1,017	338	213	35
Cl		1,521	512	324	53
Ti		8,274	2,812	1,821	321
Fe			8,696	5,061	940
Cu				9,107	1,781
Zn					2,152

Advantage of AttoMap™'s Dual Energy

The table above shows selected fluorescence cross-sections of various elements as a function of x-ray excitation energy due to source target material choice. Note that cross-sections (related to the capability to excite fluorescence) can vary by orders of magnitude depending on x-ray target material. AttoMap™ provides access to multiple target materials so that performance is optimized for the full range of elements. Target selections are customizable.

AttoMap™: Modular Design & Specifications

The AttoMap system was designed as the laboratory analogue of a synchrotron x-ray microanalytical microscope capable of a variety of techniques with room for planned upgrades such as microXRD. Standard configuration options currently feature a micro x-ray fluorescence module, a 2D transmission x-ray imaging module, and an optical microscope module.

Parameter	Specification
Spot Size	High Res (<8 µm) | Med Res additional optics also available
Sensitivity	Sub-ppm relative detection sensitivity and capable of mapping trace elements. Picogram to femtogram absolute sensitvity (element & acquisition time dependent)
Additional Capabilities & Modules	2D correlative x-ray imaging at <1.5 µm resolution included (standard) Optical microscopy included (standard) Future modules will be available as upgrades
Footprint	54″ W x 65.5″ H x 38.5″ D
Maximum Sample Size	50 cm x 50 cm | 15 cm thickness
Source	Sigray High Brightness Microfocus Source
Target Material	Dual Energy Option, includes selection from: Cr, Cu, Rh, W, Pt, etc. Custom target options include materials that have previously ***not been used*** in conventional sources.
Power | Voltage | Current	50 W | 20-50 kV | 4 mA
X-ray Optic	Sigray Twin Paraboloidal X-ray Optics (matched to each target material)
Transmission Efficiency	~80%
Working Distance	10 - 50 mm (customizable)
Interior Coating	Platinum (increases NA of optic significantly)
X-ray Detectors	SDD Detector and an X-ray Camera Optional 2nd SDD Detector
Energy Resolution	<135 eV at Mn-Ka

Sigray AttoMap™ is designed for ultimate flexibility: its modular design enables upgrades with additional techniques and its convertible staging design allows operation both vertically (microXRF mode) and horizontally (beamline mode)

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