Microspectroscopy - XFM

The microspectroscopy beamline offers a range of x-ray absorption and fluorescence spectroscopy techniques at submicron length-scales. The beamline has two microscopes optimised for complementary studies. A KB mirror microscope is optimised for applications requiring high flux at 5-micron length scales. A zone-plate microscope can be used to obtain extremely high-resolution maps at the 100-nm length scale. Both systems can be used to obtain maps of elemental distribution and for a range of spectroscopic applications such as determining target-atom oxidation state or coordination geometry.

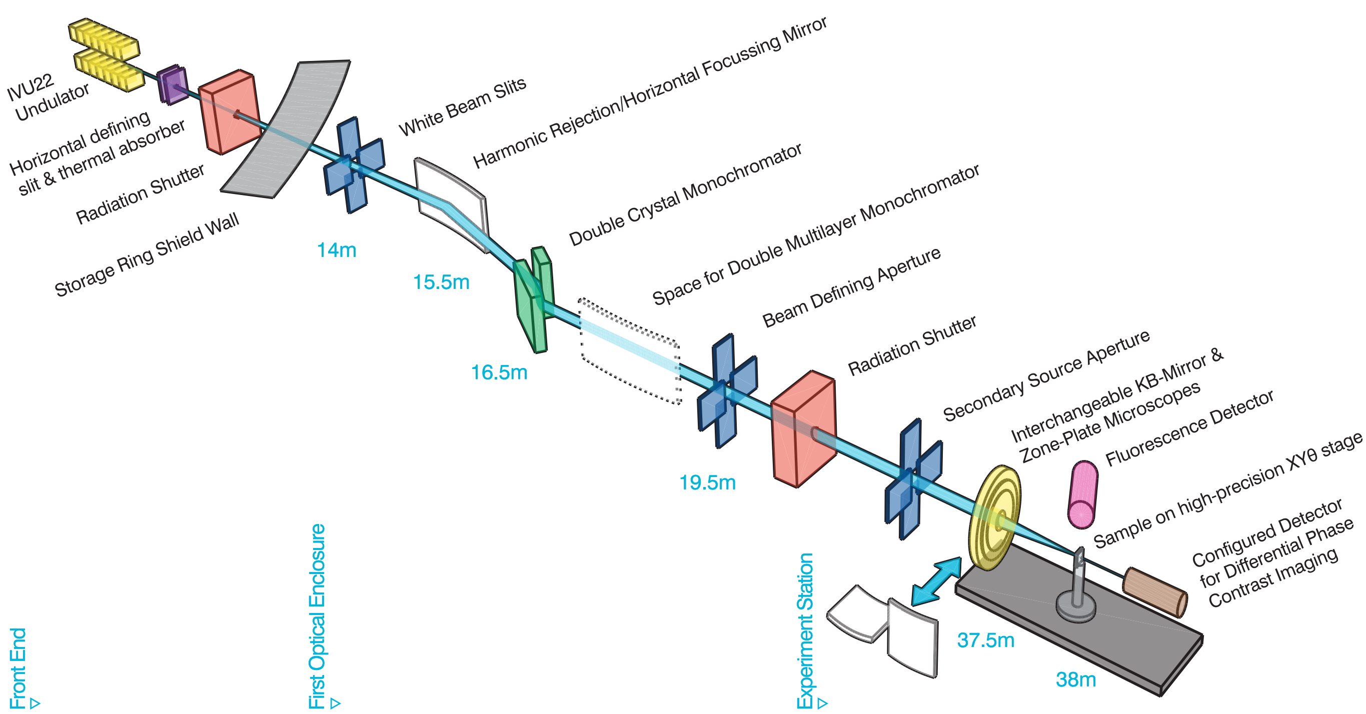
Features

Also called an x-ray fluorescence microprobe (XFM), this beamline offers:

- complementary analyses at medium and high energy:
  - XAS (x-ray absorption spectroscopy)
  - XANES (x-ray absorption near-edge structure)
  - EXAFS (extended x-ray absorption fine structure)
  - XRF (x-ray fluorescence)
- energy range covering the K absorption edges of elements from titanium up to silver
- high brightness, enabling high sensitivity (dilute samples) and fast acquisition (short dwell)
- advanced fluorescence and differential phase contrast detectors
- tuneable beam excitation energy, enabling analysis of individual elements within a sample.

Applications

Synchrotron microprobes use x-ray absorption and fluorescence emission spectroscopy techniques to obtain valuable elemental, structural and chemical information from a very diverse range of samples with submicron resolution. Life science applications include drug design, bio-sensors, sub-cellular imaging and bio-remediation. Physical science applications include studies of advanced materials, ceramics, nanomaterials, composites, chemical reactions and catalysts, as well as forensic investigations and mineral exploration and beneficiation work.



Examples

- studies of the spatial distribution and chemical properties of metalloproteins, particularly those containing Se, in cells and tissues are improving our knowledge of the functionality of these species
- structural chemical information on the distribution, uptake and intracellular biotransformation of metal-containing pharmaceuticals
- investigation of mineral formation and weathering processes; development of better methods for dealing with mine waste; analysis of extraterrestrial materials to shed light on the evolution of the planets and solar system
- materials science applications include studies of surface corrosion and wear mechanisms, photovoltaic materials, fuel cell electrodes, polymer seeding and crystallisation, and the impact of impurities and contaminants on recycling processes.

Case study 1

Fertiliser uptake in soils

Australian farmers spend more than $1.6 billion on phosphorus fertilisers a year, but soils that are highly alkaline or acidic can rapidly change fertiliser phosphorus into forms that are not readily accessible by plants. More efficient use of phosphorus fertilisers would save farmers money as well as reducing the potential for phosphorus runoff to affect rivers and lakes adversely. Dr Enzo Lombi, formerly of CSIRO and the South Australian Research and Development Institute and now at the University of Copenhagen, and Dr Roger Armstrong from the Victorian Department of Primary Industries are using synchrotron micro-XRF and micro-XANES to conduct *in-situ* studies of the fundamental processes that control the availability of fertiliser phosphorus. Results so far have confirmed the team's assumptions and provided additional mechanistic insights. The findings will help to determine whether granular or fluid fertilisers are the best option for particular soil conditions.

Case study 2

Air pollution particulate characterisation

ANSTO researcher Dr David Cohen and colleagues are using micro-XRF to characterise particles contributing to air pollution in the Sydney basin and accurately identify the sources from nature or industry. Once the sources are identified, steps can be taken to reduce the problem.

Case study 3

Forensic studies: what killed Phar Lap?

Since Australia's most famous racehorse, Phar Lap, died suddenly in California in 1932, many people have speculated that the champion was poisoned. Dr Ivan Kempson from the Ian Wark Research Institute at the University of South Australia and US researchers recently examined a 2 mm square sample of hide from under Phar Lap's mane using synchrotron micro-XRF and micro-XANES techniques. They found a very high concentration of arsenic inside the hair just below the skin—consistent with a large dose. Based on the rate of horse hair growth, and the way arsenic peaks in the blood, the results show the poison was ingested in the 30 hours before death. This finding would not have been possible using other methods. Kempson is working with the National Institute of Forensic Science to develop synchrotron methods for crime investigation.

Beamline specifications

Source	in-vacuum undulator, n = 90, 22 mm period			
Energy range	4.1-25 keV			
Optimal energy range	5-12 keV			
Energy resolution	$\Delta E/E = 10^{-4}$			
Beam properties at 10 keV	**Focussing method**	no focussing	KB mirrors	zone plate
	Spot size	0.6 mm x 1 mm	5 μm	100 nm
	Flux (photons/s)	10^{12}	4×10^{11}	10^{10}
	Flux density (photons/s/μm^2)	1.6×10^{6}	1.5×10^{10}	1×10^{12}

Contact info

David Paterson (pictured), Martin de Jonge, Daryl Howard
Phone **+61 3 8540 4165**
Email **xfm@synchrotron.org.au**
Web **www.synchrotron.org.au**

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