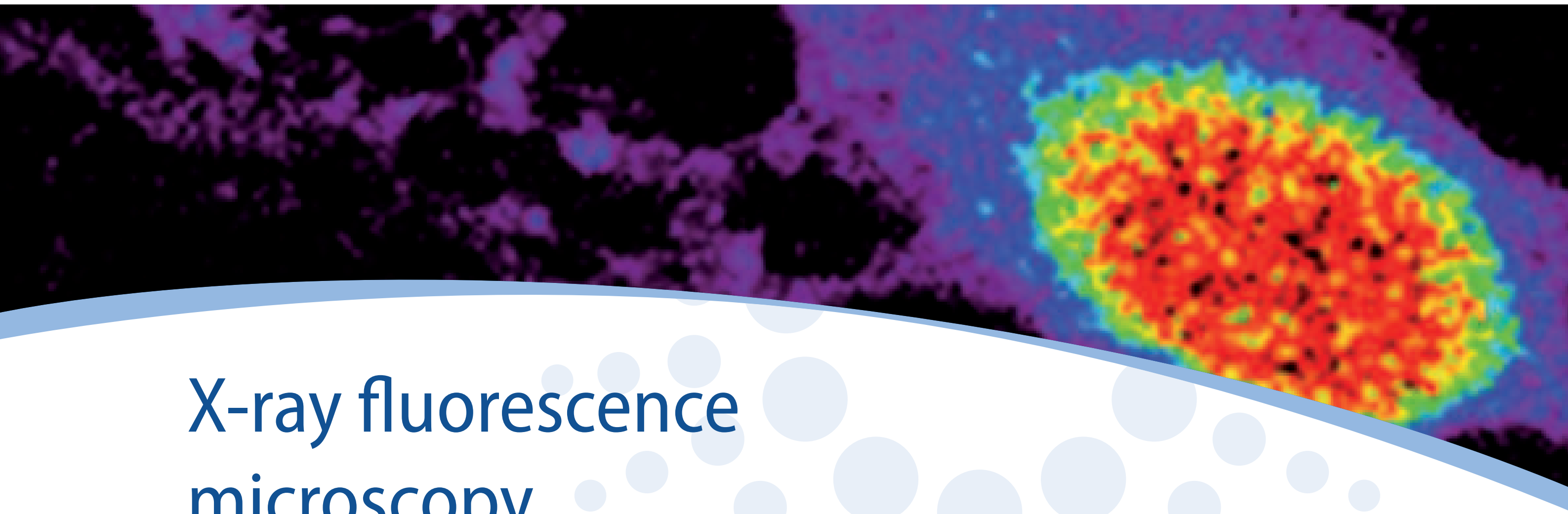

X-ray fluorescence microscopy

The technology at a glance

X-ray fluorescence microscopy and microspectroscopy use very fine high-quality beams, focused on extremely small areas within heterogeneous materials. For example, irradiation of trace elements within hard or soft substances enables scientists to probe deeply and isolate minute quantities of substances within a large volume. This enables new investigations, such as access to elements of major interest in the biological and material sciences, identification of heavy metals and trace element mapping, with very little preparation needed for the materials being used.

The added value of the ESRF X-ray fluorescence microscopy facilities

The ESRF has a suite of four beamlines (ID13, ID18F, ID21, ID22) fully dedicated to microscopy and microspectroscopy techniques. In particular, ID22 is a versatile hard X-ray microprobe focused on X-ray fluorescence, absorption and diffraction on the micrometre scale. The three beamlines enable a variety of different approaches to be combined, including fluorescence tomography, XANES imaging, holography and phase-contrast microtomography with micrometre resolution. Their potential for detecting and mapping trace elements, quantitative fluorescence analysis, chemical state specificity and structural probing is ideal for a wide range of industrial applications.

> "How precise are our probing techniques for finding trace elements? You could pour a glass of wine into an Olympic swimming pool and we could tell you if it was Bordeaux or Burgundy."
>
> - Jean Susini, Head of Instrumentation Support and Development Division

Fields of application

Environmental science: trace elements, including identification of toxic concentrations of heavy metals, analysis of air pollution filters, etc.

Earth and planetary science: analysis of minute samples to study bulk morphology, internal structures, crystallography and trace composition, used for example to study a cometary grain collected by the NASA Stardust mission.

Microelectronics: identification of metallic microcontamination levels in microprocessors and integrated circuits, improvement of silicon wafers.

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Cosmetics: in-depth knowledge of the interaction between cosmetic substances and living organisms.
Cultural heritage and archaeology: study of art masterpieces (Grünewald Triptych, Van Gogh painting) and stone samples (Pompeii).
Oil industry: analysis of trace elements in petroleum and petrochemical products.

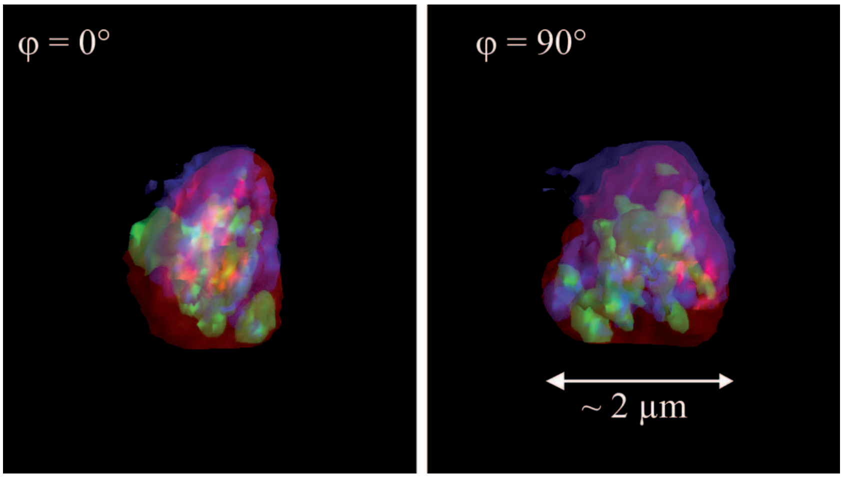
> "Our main motivation for coming to the ESRF is the guarantee that we will find exactly what we expect. The beamline is always set up according to our needs and we always reach our objective."
> - Phi-Axis (a small service company)

Corporate clients include CEA, Lafarge, L'Oréal, Saint-Gobain

CASE STUDY

X-ray fluorescence nanotomography on cometary matter from Comet 81P/Wild2 returned by the NASA Stardust mission.

The challenge: To determine the 3D distribution of main and trace elements in a cometary dust particle embedded in an aerogel matrix.
Background: The NASA Stardust mission captured and returned extremely precious cometary dust particles to Earth. The particles were captured in space using an aerogel matrix to stop and trap the dust particles. The terminal particles captured are around 2 microns in size.
Results: Fully 3D, non-destructive, trace-level elemental imaging was made on a dust particle showing the distribution of elements from calcium to selenium at sub-micron (200nm) spatial resolution.
How did the synchrotron help? X-rays are an element-selective, non-destructive probe. The very fine X-ray beams available on beamline ID13 (the ESRF pilot project for further nano-focus X-ray beams), enabled nanotomographic images of the minute cometary dust particles to be recorded and transformed into the full 3D reconstruction.
Reference: Silversmit et al. Anal. Chem. (2009). In press.



The reconstructed comet dust particle with colours showing the distribution of different elements (red: iron; green: chromium; blue: selenium).

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