ESRF	**Experiment title:** 3D X-ray microtomography using ID21 Transmission X-ray Microscope	**Experiment number**: MI 460
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Report:

This tomography experiment was finally performed using the Scanning X-ray Microscope (SXM) of ID21 instead of the Transmission X-ray Microscope. The idea was to take advantage of the SXM capabilities in terms of fluorescence mapping to perform **3D elemental mapping** in addition to transmission tomography. The microscope was operated at 5.5 keV (Si111 double-crystal fixed-exit monochromator). A Fresnel zone-plate was used to focus the x-ray beam to a submicron microprobe (0.4 x 0.6 μm^2). A high precision rotation stage, specially designed for tomographic data acquisition, was mounted on the piezoelectric sample stage of the SXM to allow data collection at different viewing angles. Both transmission and fluorescence signals from the sample were collected simultaneously using respectively a Si photodiode and a Hp Ge detector. A schematic of the data acquisition geometry, which corresponds to "first generation" tomography, is presented in fig. 1.

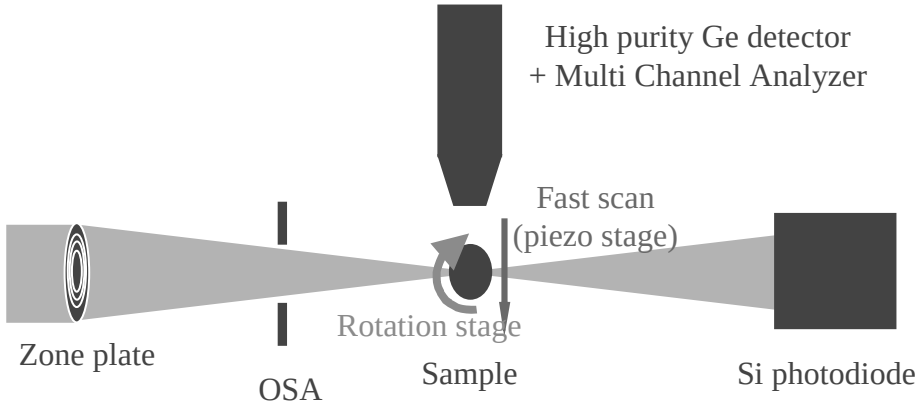

Figure 1: Tomographic setup

Prior to data acquisition, the sample must be precisely centered on the rotation axis of the stage, so as to limit its excursion during rotation and ensure that it remains in the 100 μm wide field of view of the microscope. This condition is essential for tomographic reconstruction. The prealignment was performed outside the microscope on a specially designed bench equipped with a videomicroscope and a micro-manipulator.

Hairs were imaged, which appeared as relevant test objects for the following reasons; their simple shape constitutes a good test for geometrical distortions related to tomographic reconstruction; we know that they

exhibit both a uniform sulfur distribution and a localized calcium distribution, as evidenced by 2D mapping of thin hair sections performed in a previous experiment (Doucet *et al.*, LS1570).

Data acquisition was performed “slice-by-slice”. The sample was iteratively scanned point-by-point in the beam horizontally, and rotated by small angular increments (1° here) over 180°, generating a sinogram (see fig. 2) of the sample slice under investigation. The sample was then translated vertically to the next slice, and the procedure repeated to obtain a 3D data set (see fig. 3). The dimensions of the sample did not exceed the depth of focus of the zone plate (100 µm). The sinograms could therefore be regarded as parallel projections, justifying the use of classical Filtered Back-Projection (FBP) algorithm for the reconstruction of the absorption images. FBP was also used for reconstruction of fluorescence sinograms, which is obviously a very rough approximation, since fluorescence self-absorption by the sample should be taken into account. This effect can clearly be seen on the sinograms, which farthest side from Ge detector (right-hand side) is attenuated.

As a conclusion, this experiment demonstrated the possibility to perform fluo-tomography using ID21 SXM, provided appropriate reconstruction software. The long acquisition time required for 3D mapping of trace elements may be a serious concern for the technique. The solution could consist of an increase of the photon flux by using multilayers for beam monochromatization.

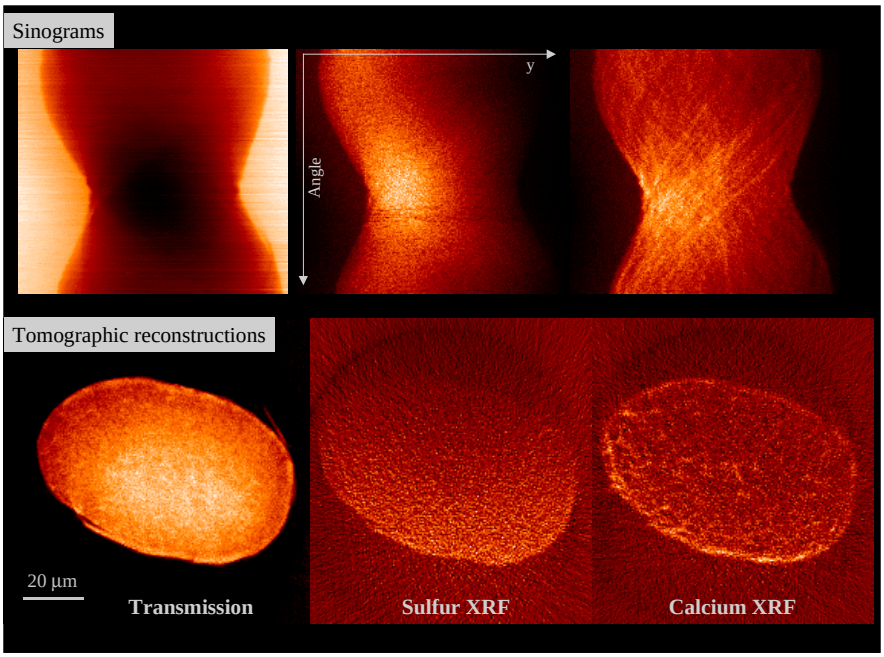

Figure 2: Hair sample. Upper raw: transmission, sulfur and calcium fluorescence sinograms, 1 µm step size, 300 ms /point. Lower raw: tomographic reconstructions of the corresponding sample slice.

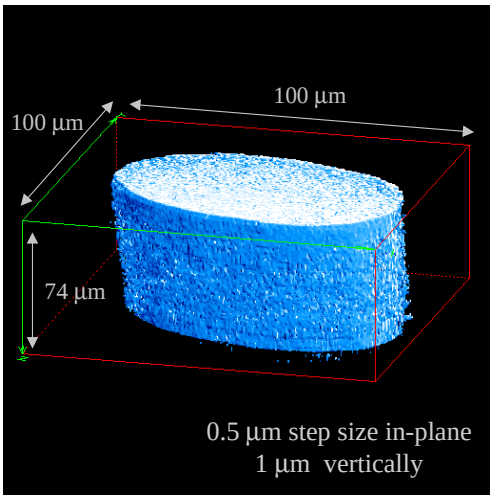

Figure 3: 3D tomographic reconstruction of a hair in transmission, 50 ms/point