ESRF	**Experiment title:** Hard X-ray Nanoprobe for Fluorescence Tomography, Nanodiffraction, and Coherent Diffraction Imaging	**Experiment number:** MI-836
Beamline: ID13	**Date of experiment:** from: Feb. 7, 2008 to: March 4, 2008	**Date of report:** April 4, 2009
Shifts: 33	**Local contact(s):** S. Schoeder, M. Burghammer, C. Riekel	*Received at ESRF:*

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Report:

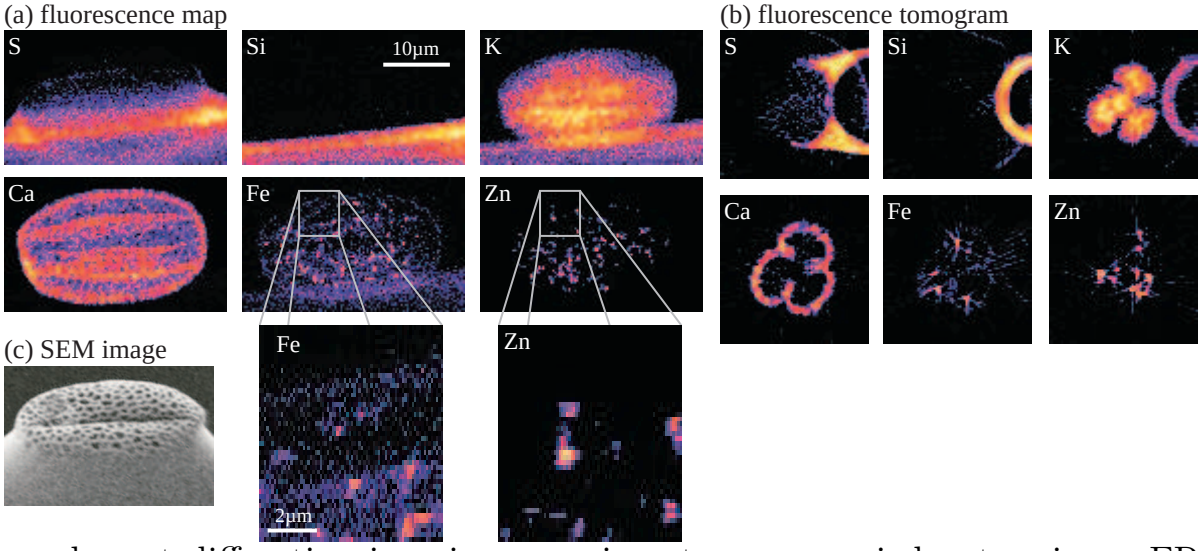
The aim of this experiment was to setup the prototypical hard x-ray nanoprobe designed and build by TUD in EH2 of ID13, carry out a series of different test experiments characterizing its performance, and subsequently supporting the user experiments CH-1923, SC-2488, and SI-1605 carried out with this setup.

The first week (16-bunch mode) was used to setup the instrument and characterize the focus in terms of size and flux. Using a fluorescence knife-edge technique, a focus of 140×150 nm^2 was measured at $E = 15.25$ keV. Using two sets of prefocusing optics (1, 2, or 3 Be-CRLs built into the BL at 28.5 m and 12 Be-CRLs installed at 41 m, experiment at 44 m) the flux on the sample could be varied between 10^8 and 10^9 ph/s. With maximal prefocusing, the beam size increased to 250×240 nm^2.

During the second week of beamtime (uniform filling), scanning microscopy experiments in fluorescence mode and coherent diffraction imaging experiments with the nanofocused beam were carried out. Several fluorescence maps of a pollen sample of *Arabidopsis thaliana* (provided by W. Schröder from FZ Jülich, Germany, cf. SEM image in Fig. 1(c)) were carried out. Fig. 1(a) shows fluorescence maps of the sample with 300 nm pixel size for overview images, and 100 nm pixel size for detail images. Small Iron agglomerations inside the pollen that are of the order of one pixel in size illustrate the high resolution achieved in these scans. In addition to the maps, fluorescence tomograms with 300 nm pixel size were recorded of the pollen sample. The reconstructions of a slice are shown in Fig. 1(b). While the K concentration inside the pollen is rather homogeneous, Ca is mainly found in its shell. Sulfur is mainly in the glue, with which the pollen was mounted on a glass capillary, and the small spots of high metal concentrations are shown to lie in the bulk of the pollen. (Manuscript

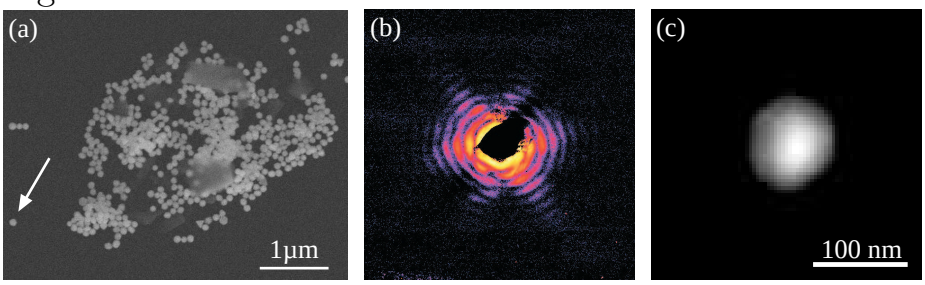
in preparation.)

Figure 1:



The coherent diffraction imaging experiments were carried out, using a FReLoN 4M diffraction camera (borrowed from ID11) with 50 μm pixel size at a distance of 1.25 m from the sample. They were intended to assess the coherence in the microbeam that is predicted to be high in diffraction limited beams [1]. As test objects served gold nanoparticles deposited on a silicon-nitride membrane. One particular object was the single gold particle pointed to by the arrow in Fig. 2(a). It was illuminated with the nanofocused beam in a series of 60 s exposures. Fig. 2(b) shows the diffraction pattern of this object, having good fringe visibility and demonstrating a high degree of spatial coherence in the focus. From this diffraction pattern, the real space image (projection of electron density) could be reconstructed with the unprecedented spatial resolution of 5 nm ([1], ESRF press release, ESRF Spotlight on Science 68). Further diffraction data was acquired at higher flux (prefocusing), showing a high degree of coherence as well. A ptychographic scan of a pair of gold particles was acquired. The corresponding data is currently evaluated.

Figure 2:



In the following two weeks of beamtime, the nanoprobe was used to carry out a series of user experiments (CH-1923, SC-2488, and SI-1605). During this time, it performed stably without the need for any realignment. Particularly successful was the SI-1605 by Hanke, et al., in which a scanning microdiffraction experiment on single SiGe-Islands was carried out ([2], ESRF Spotlight on Science 64).

The data from a scanning fluorescence microscopy experiment carried out during CH-1923 on samples from the Stardust mission is still evaluated.

References

[1] C. G. Schroer *et al.*, Phys. Rev. Lett. **101**, 090801 (2008).

[2] M. Hanke *et al.*, Appl. Phys. Lett. **92**, 193109 (2008).