ESRF	**Experiment title: Combined AFM and scanning near-field x-ray microscope for 10nm resolution, at water window wavelengths**	**Experiment Number:** MI-348
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Report:

1. Introduction.

The new scanning X-ray microscope (STXM) with a tubular collimator downstream of a condenser zone plate was developed for imaging at high spatial resolution with X-rays of energy ~400ev, i.e. in the water window. In the present experiment, as in the previous experiments, photons were available at a a higher energy, this time of 3.3kev. Tubular collimators effective at this energy require to be about 2-3um long and to improve the resolution available directly with zone plates the collimator aperture requires to be 150nm or less. Apertures with this range of aspect ratio have not yet been made.

As a consequence the experiment was redirected towards a further investigation of the new facility provided by this microscope of simultaneous imaging of the surface topography of the specimen and the soft X-ray transmission. The former is provided by the AFM tip, introduced for two reasons, first to provide a vehicle, by drilling, for the tubular collimator, and second to maintain the specimen at a constant distance of a few nm from the exit aperture of the tubular collimator.

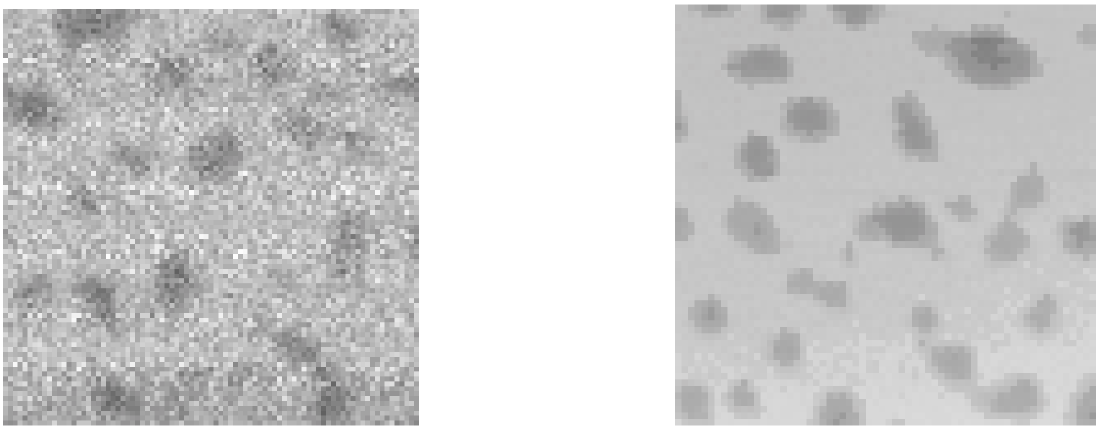
In the absence of the tubular collimator the AFM tip was used to provide the surface topography only and the X-irradiation of the specimen was provided by -what was to be-the condenser zone plate developed for high energy X-rays by P. Charalambous. Consequently the absorption image and the topographic image were taken simultaneously but with areas that were displaced from one another by a few um in virtue of the independence of the two facilities.

2. **Experimental**

Concentration on the tip adjustments and optical system for the measurements on tip deflection, while also accounting for the adjustments needed when the drilled tip acts as a tubular collimator, was extremely beneficial, as was the movement towards more general specimens than had been used previously. These adjustments are not readily made and much time has been spent evaluating a working protocol.

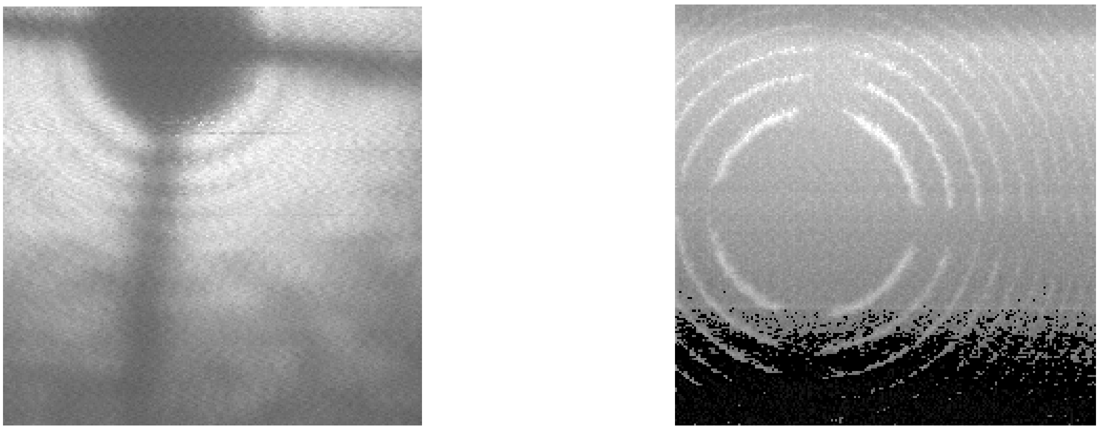
The adjustments in a confined space governed by the 6mm focal length of the zone plate collimator involve the lateral positioning of the zone plate, the introduction and alignment of the order selecting aperture and the positional and angular setting of the AFM tip assembly with the specimen topography being measured in contact mode.The physical conditions for apparatus development at 3.3kev photon energy are considerably more relaxed than for water window energies as the focal length of the zone plate is increased proportional to the energy. Following the experience and the measurements taken on this run the tip adjustment and orientation module has been redesigned to be more flexible to accommodate energy changes, to reduce the dependency of adjustments, and be at the same time more flexible.

In Figures 1 and 2 are shown comparisons of similar adjacent image fields taken of X-ray transmission and of surface topography. The images are respectively of copper islands about 500nm thick and with similar lateral dimensions and the inner zones of tungsten zone plates developed for imaging with high energy X-rays, also about 500nm thick and with similar ring separations.



(a) **(b)**

Figure 1(a), (b) Comparison of images of copper islands in X-ray transmission (a), and by surface topography (b). Islands are roughly spherical with diameter ~500nm. Photon energy 3.3kev.



(a) **(b)**

Figure 2(a),(b) Comparison as in Figure 1, Tungsten zone plate, both thickness and zone separation ~500nm.