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A novel X-ray fluorescence microscope for movie applications

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Introduction

Recent progresses in synchrotron microbeam technologies have made micro X-ray fluorescence (XRF) imaging extremely attractive and feasible in many kinds of scientific applications [1]. The imaging is, however, usually not dynamic, because the technique uses 2D scans that require a fairly long measuring time. Our previous experiences [2,3] indicate that non-scanning imaging can be a good alternative for quick observation. This report describes the instrumentation of an XRF microscope suitable for recording digital movies.

Instrumentation

The main idea of the present non-scanning XRF microscope has been described elsewhere [2]. A grazing-incidence arrangement is employed to make primary X-rays illuminate the whole sample surface. Parallel-beam optics and extremely-close-geometry (the clearance is ~0.5mm or less) are adopted in order to detect XRF with a CCD camera. In the previous experiments, a sideways-looking arrangement was used for the CCD camera, which meant the sample had to be stood up and had a vertical rotation axis. This was necessary to protect both the sample and the window for the CCD camera from accidents because of the very close geometry prevailing at that time, but a completely different design is required for movie applications. The microscope allows much more freedom for the location of the sample. In particular, the sample needs to be laid in the plane.

Figure 1 shows a photograph of our new XRF microscope. A CCD camera is mounted on the frame with a downward-looking arrangement. The sample has XY stages like a usual optical microscope, and several manual stages for height (i.e, distance to the camera) and titling. The experiments do not use total-reflection, and the glancing angle is usually set at 1~1.5 deg. Instead of employing any focusing optics, the natural linear shape of the synchrotron beam is used. The size is 0.3mm(V) x 12mm (H).

Results

Figure 2 shows part of the XRF digital movie for an ion exchanging reaction. Particles of resin (Dowex A-1) are put on a filter paper filled with $CuSO_4$ solution. The X-ray energy is set at 9.1 keV (above Cu-K edge). Exposure (1min) is sequentially repeated during the reaction. The image corresponds to the concentration distribution of copper. It has been confirmed that the exchange starts from the surface of each resin particle, and then the reaction proceeds inside. The estimated spatial resolution is around 20 µm. One can see that the present microscope is successful in obtaining a digital XRF movie, which has been extremely difficult so far. It is now possible to perform dynamic observation of the reaction in progress at the sample stage of the microscope.
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References

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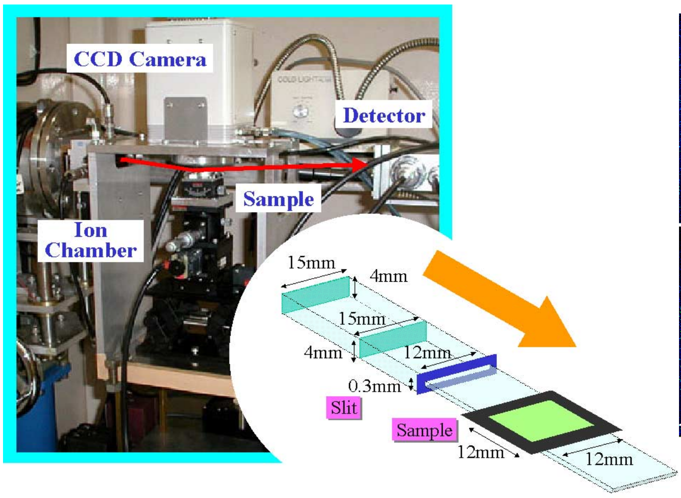

Figure 1 X-ray fluorescence microscope for movie applications

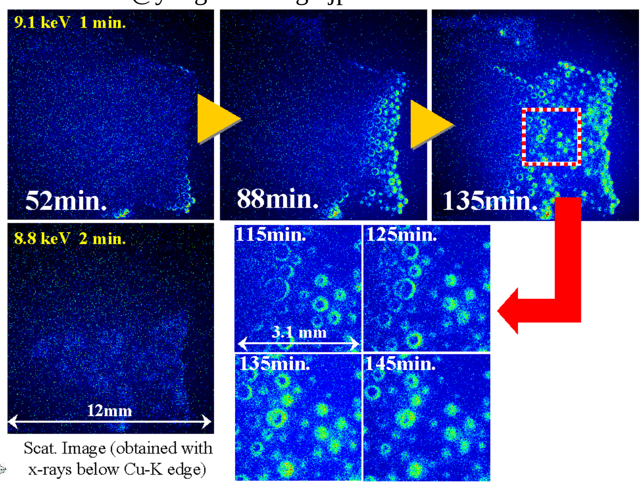

Fig. 2 Digital X-ray fluorescence movie for an ion exchanging reaction. The images show how copper ions are adsorbed into the resin.