HIGH SPATIAL RESOLUTION X-RAY FLUORESCENCE IMAGING BY IMAGE RECONSTRUCTION TECHNIQUE USING SYNCHROTRON RADIATION

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Abstract - A high spatial resolution X-ray fluorescence imaging with monochromatized synchrotron radiation has been developed by the image reconstruction technique that employs a line-beam. To adopt a novel beam demagnifier using an asymmetric reflection of a crystal, a narrow line-beam of a few microns was obtained. XRF images were obtained with good spatial resolution in the order of a few microns. An application to the chemical state imaging using the chemical shift of the X-ray absorption edge was also demonstrated.

Key words XRF imaging, image reconstruction technique, synchrotron radiation, chemical state imaging

X-ray fluorescence (XRF) imaging is a promising method for non-destructive element mapping. Using synchrotron radiation (SR), it is expected to improve spatial resolution and sensitivity. In practical, however, it is difficult to achieve the SR XRF imaging with high spatial resolution in the order of a few microns, because it is difficult to obtain micron-order x-ray beam with sufficient intensity due to difficulty of x-ray focusing. A point-shaped x-ray beam with x-z sample scanning is commonly used for XRF imaging. As an alternative method, XRF imaging is possible by the image reconstruction technique [1]. In this technique, a line-shaped incident beam is used with rotational and translational scanning of a sample. One of the advantages of this technique is an increased XRF signal intensity compared with the technique that uses the point-shaped beam.

We have developed a high spatial resolution XRF imaging system by the image reconstruction technique using monochromatized SR [2]. To achieve high spatial resolution, we adopted a novel beam demagnifier system using the asymmetric Bragg reflection of a crystal.

In this paper, we describe our XRF imaging system which was improved in precision of its scanning system. We also describe an application to the chemical state imaging [3] with this system.

EXPERIMENTAL

The experiment was carried out using SR at the Photon Factory (PF) on beam-line 4A. An experimental setup of the XRF imaging system is shown in Fig.1. A sample was mounted on the rotational stage and the translational stage. The XRF signal was measured by Si(Li) detector under the atmospheric condition.

Fig.1 Experimental arrangement for the high spatial resolution XRF imaging by the image reconstruction technique.
To achieve the high spatial resolution XRF imaging by the image reconstruction technique, it is necessary to obtain a narrow and intense line-shaped x-ray beam. We adopted a beam demagnifier system using the asymmetric reflection and a sagittal focusing double crystal monochromator for vertical and horizontal beam demagnification respectively. We calculated the beam-width and intensity of the demagnified beam obtained by this system.

We improved the precision of the sample scanning system, because the instrumental error of scanning during the measurement caused artifacts in the reconstructed images. To minimize the artifacts caused by the fluctuation of the rotational axis during revolution, we used the rotational stage which had the air bearing instead of the ball bearing in latest system. The precision of the rotational axis was less than 0.1 μm and that of the translation stage was less than 0.05 μm. For precise setting of the beam position, we used an optical microscope.

**RESULT AND DISCUSSION**

By the beam demagnifier system using asymmetric reflection, a line-shaped beam of a few microns was obtained and the beam width was in good agreement with the calculation. The XRF images of Ni grids and several mineralogical samples were obtained with high spatial resolution of less than 5 μm. Reconstructed images had almost no artifacts as the results of the improvement of the scanning system.

The chemical state imaging was also demonstrated with high spatial resolution. When elements in the different chemical state are excited with x-ray which is monochromatized near the x-ray absorption edge, there are small differences in the XRF intensities among the species due to the chemical shift of the absorption edge. Using this difference, chemical state analysis is possible. The chemical state images can be separated from XRF images measured with different excitation energies. Fig.3 shows the separated chemical state images of the iron oxides (Fe2O3, Fe3O4) in the sintered iron ore sample. The separated images were clearly obtained with the spatial resolution of about 5 μm. These images corresponded with the optical image.

To obtain more intense x-ray line-beam, the development of a system with an elliptical mirror for vertical focusing is now under way.

**REFERENCES**


Fig.2 The separated chemical state images of the sintered iron ore. (a) optical microscope image, (b) Fe2O3 image, (c) Fe3O4 image
measured area :280 μm², beam width :5μm