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Energy-dispersive diffraction imaging with white X-rays

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Introduction

X-ray diffraction (XRD) imaging can be performed by combining an energy scan of the incident beam and a completely fixed specimen-CCD geometry based on a projection-type X-ray microscope [1]. This report describes another procedure for obtaining an XRD image using white X-rays. The present experiment employs a CCD device as an energy-dispersive detector.

Experimental

The instrument used is essentially the same as a projection-type X-ray fluorescence (XRF) microscope [1]. Since this experiment employs the single photon counting mode of a CCD camera, pixels needs to be read out extremely fast. Technical details of the CCD (TC281, Texas Instruments) used in the present study are described elsewhere [2]. A platinum-coated flat mirror was used to remove the higher-energy component above 12 keV. Typical exposure time for one image was 5~30 msec. Exposure was repeated 1024 times, and each time, all pixels were set as 1 or 0, depending on whether the ADC level was within the region of interest or not. The sum of those images produces a map for the specific diffraction peak, i.e., the lattice spacing. The sample measured is a polycrystalline molybdenum substrate (bcc, a=3.1472 Å).

Results and Discussion

Figure 1 shows a histogram of the charge amount (ADC level) for 1000 × 1000 pixels when a very short exposure was repeated 256 times. This roughly corresponds to the diffraction pattern obtained by the energy-dispersive method. Two rather clear peaks found at 380 and 450, correspond to X-ray energy of ca. 5500 eV and 7800 eV, respectively. They are interpreted as (200) and (220) reflections, because the 2d values calculated from those energy levels and the Bragg angle of ca. 90 deg agree quite well with 3.1476Å and 2.2258Å, respectively. A broad weak peak observed at around 600 is due to the scattering background of incident X-rays.

In the present study, the region of interest for (220) reflection was set as 435~472 in the ADC level, corresponding to the energy window at ca. 7260~8380 eV. Figure 2 shows the X-ray image of this energy range obtained by the single photon counting procedure. One can see some spotty patterns, which are randomly distributed in the viewing area of 8mm×8mm. Since the spatial resolution of this microscope is 15~20 micron, quite large grains are observed. In contrast, the diffracted X-ray is strongly oriented and is almost independent of the surface morphology, while the image is influenced by the size or shape of crystal grains. The authors wish to thank Dr. M. Shoji for his help in analysing images by the single photon counting method.

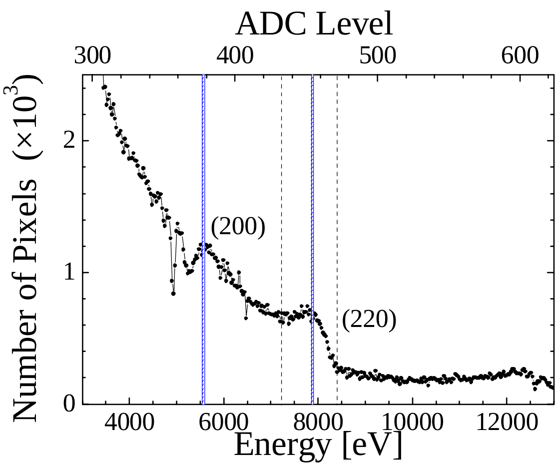

Figure 1 Histogram of the charge amount (ADC level) created in the CCD device (TC281, Texas Instruments) by an extremely short exposure to white X–rays at BL-4A. Blue lines indicate the diffraction peaks of polycrystalline molybdenum. The diffraction plane is inclined at ca. 45 deg to the surface.

References

[1] K.Sakurai and M.Mizusawa, *Photon Factory Activity Report*, this issue.
[2] K.Sakurai and M.Mizusawa, *AIP Conference Proceedings* (SRI- 2003, San Francisco, USA) in press.
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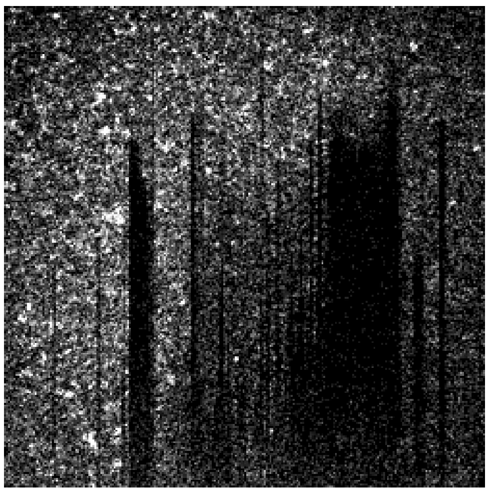

Figure 2 X-ray image of a polycrystalline molybdenum substrate obtained by the single photon counting method. The image is for 7260~8380 eV X-rays, and corresponds to (220) reflection (See Fig.1). One can see individual grains, because of their quite large size (30~70 micron). Vertical stripes should be ignored and represent unexpected damage to pixels during the course of adjustments just prior to the experiments.