Scanning Transmission X-ray Microscopy with Momentum Analyzer

Yoshio Suzuki, Akihisa Takeuchi, and Hidekazu Takano*

JASRI/SPring-8, Mikazuki, Hyogo 679-5198, Japan
**Univ. Hyogo, Kamigori, Hyogo 678-1297, Japan*

X-ray topography is widely used for characterizing dislocations and defects in single crystal samples. The spatial resolution of the topographic image is usually a few μm that is limited by both the Fresnel diffraction and detector's spatial resolution. The scanning microscopy with diffracted-X-ray-detection method, so called "scanning topography", may be applied to high-spatial-resolution topographic imaging, because the spatial resolution of the image is determined by the spot size of the focused beam.

However, when a convergent beam is diffracted by a nearly perfect crystal, only a small portion of incident beam is propagated to the detector, because the diffraction occurs within a narrow angular range that is smaller than the angular width of the incident beam. The spatial resolution of scanning microscopy image is limited by the diffraction theory of light, that is expressed by $\Delta x = 0.61\lambda/NA$, where the NA (Numerical Aperture) corresponds to the convergent angle of the focused beam. Therefore, it may be probable that the spatial resolution of the topographic image may be limited by not only the NA of the beam-focusing optics but also by the angular width of diffraction at the sample. In order to confirm this assumption, we have tried scanning microscopy experiment in which the transmitting beam through the test object is filtered by a crystal analyzer that selects a portion of the transmitted X-ray beam. The schematic diagram of the experimental setup is shown in Fig. 1. The experimental setup is essentially the same as that of the conventional scanning microscopy experiment, except the analyzer crystal (Si 111 Bragg reflection). Scanning microscopic images of resolution test patterns were taken in order to characterize the imaging properties.

In the measured images, strong artifacts (edge-enhancement) appear in the horizontal direction, and some deterioration of contrast is observed in the vertical direction. Therefore, it is considered that the imaging properties are determined not only by the primary focused beam but also by the acceptance for the transmitting beam.

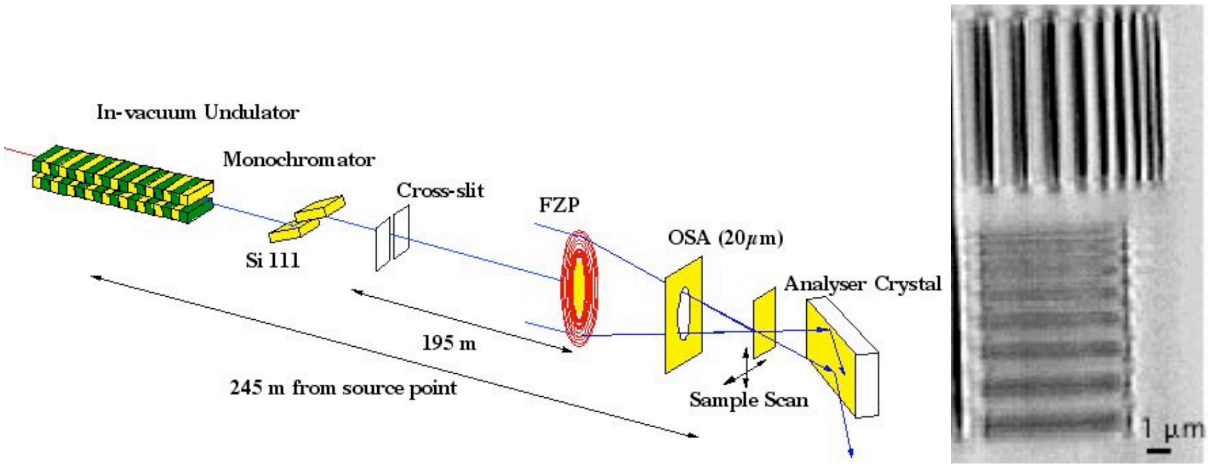

Fig. 1. Schematic diagram of experimental setup and measured image of resolution test patterns by scanning transmission X-ray microscopy with crystal analyzer. X-ray energy is 10 keV.