Crystallography

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Observation of X-Ray Mirage Fringes from a Bent Crystal

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In the Bragg case, the refracted beams propagate quite deep into the crystal when anomalous transmission occurs remarkably. In this case, even when the dispersion angle $\Delta\alpha$ of the incident beam is quite small (less than 1 arcsec), the dispersion angle of the refracted beam $\Delta\gamma$ becomes quite large, because the angle γ between the diffraction plane and the refracted beam varies from zero to approximately a Bragg angle θ_B for $\Delta\alpha$. The angle amplification $\Delta\gamma/\Delta\alpha$ is extremely large (10^5). In a bent crystal with a constant strain gradient, the paths of the refracted beams are of hyperbolic forms and the refracted beams are deflected back to the crystal surface in Fig.1. A part of the beams are diffracted from the surface at A_2, which is called as 'a mirage diffraction' [1]. The intensity profiles of the mirage diffractions have been investigated by Yan *et al.* [2]. Owing to this angle amplification, although the incident beam is regarded as a plane wave, the refracted beam works as a spherical wave. Consequently, two refracted beams $\boldsymbol{S}_1$ and $\boldsymbol{S}_2$ interfere with each other, which results in the interference fringes in the diffraction coming out of the crystal at A_3 in Fig.1. We call this fringe as 'mirage fringe' [3].

In order to observe the mirage diffraction and the mirage fringes, the experiment was carried out at the beam line BL-15A, KEK-PF. The X-rays were σ-polarized and were monochromated by using Si 111 double crystal monochromator. The X-ray energy was at 11,100eV. The sample of a Si strip of 500 mm long, 10 mm wide and 0.18 mm thick was bent by using the bending jig as shown in Fig.2. The photographs of the 220 diffraction beams recorded on the nuclear plates are shown in Fig. 3. When the displacement D of the bending jig is zero, no mirage fringes are observed, but multiple Bragg-Laue (MBL) fringes [4,5] are observed from the lateral surface as a result of the interference between two beams $\boldsymbol{S}_3$ and $\boldsymbol{S}_4$ as shown in Fig. 1. When D=90 μm, one mirage fringe $P_m^{<1>}$ is observed, and when D=130 μm, 4 mirage fringes are observed. It is possible to determine the strain parameter by using the periods of the mirage fringes [3].

The mirage fringes are very useful for estimation of crystal perfection, because they are very sensitive to small crystal distortion. They will be also useful for designing of a new X-ray interferometer.

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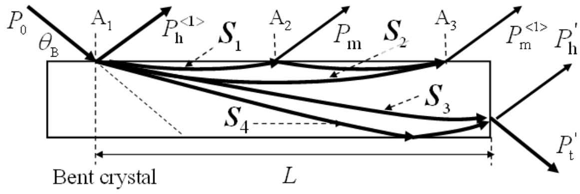

Fig. 1 Schematic diagram of mirage fringes. L is the distance between the incident point and the crystal edge.

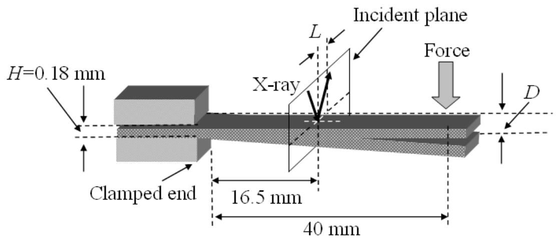

Fig. 2. Sample and bending jig geometries.

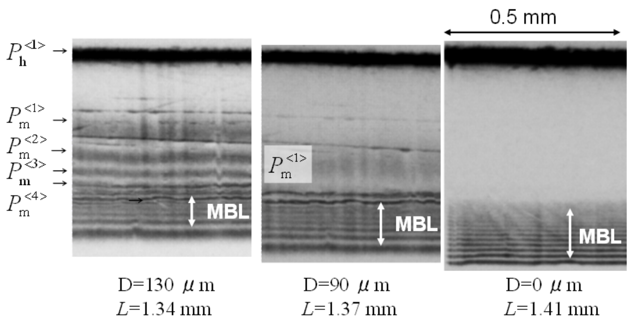

Fig. 3. Observed fringes. $P_m^{<1>} \sim P_m^{<4>}$ are the mirage fringes, $P_h^{<1>}$ is the primary diffraction at the incident point A_1 in Fig.1.

References

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