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Observation of Strain Gradient of Weekly Bent Crystal Using Mirage Fringes

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We report on the observation of strain gradient of a uniformly deformed crystal by using X-ray mirage fringes.

Under an anomalous transmission condition in the Bragg mode, the refracted beam propagates along a hyperbolic trajectory and it returns to the incident surface (mirage diffraction). The beam corresponding to the Poynting vector is called the refracted beam here. Since the refracted beam is regarded as a quasi-spherical wave, it produces several types of interference fringes such as mirage fringes [1] and IFMRB [2]. These fringe spacing decreases as the strain increases. It is possible to know the strain gradient of a bent crystal by observing interference fringes in X-ray section topographies.

The X-ray topographies of Si 220 were observed at the beam line BL-15C, KEK-PF. The X-rays were σ-polarized and monochromated using a Si 111 double-crystal monochromator. The X-ray energy was 11100 eV. The geometry of X-rays and the sample are shown in Fig. 1. Fig. 2 shows the topographies observed between the free edge and the clamped side of the sample. We can see the curved mirage fringes in the center of the sample and IFMRB near the free edge. According to the rod theory, the strain gradient is maximum at the clamped end and zero at the free edge under uniformly distributed load due to gravity. The observed spacing of mirage fringes becomes narrower around the center of the sample and IFMRB is observed even at the free edge. The former should be explained by the effect of buckling induced by the force holding the sample. The latter should be explained by the residual strain after manufacturing the sample. There still remains large discrepancy between the theoretically calculated strain and the observed one. More precise analysis should be needed to determine the strain by using the mirage fringes or IFMRB.

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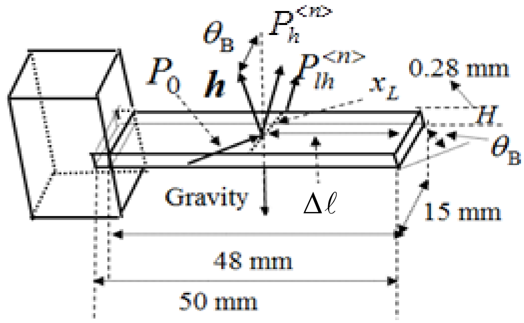

Fig.1. Geometry of X-rays and sample.

References

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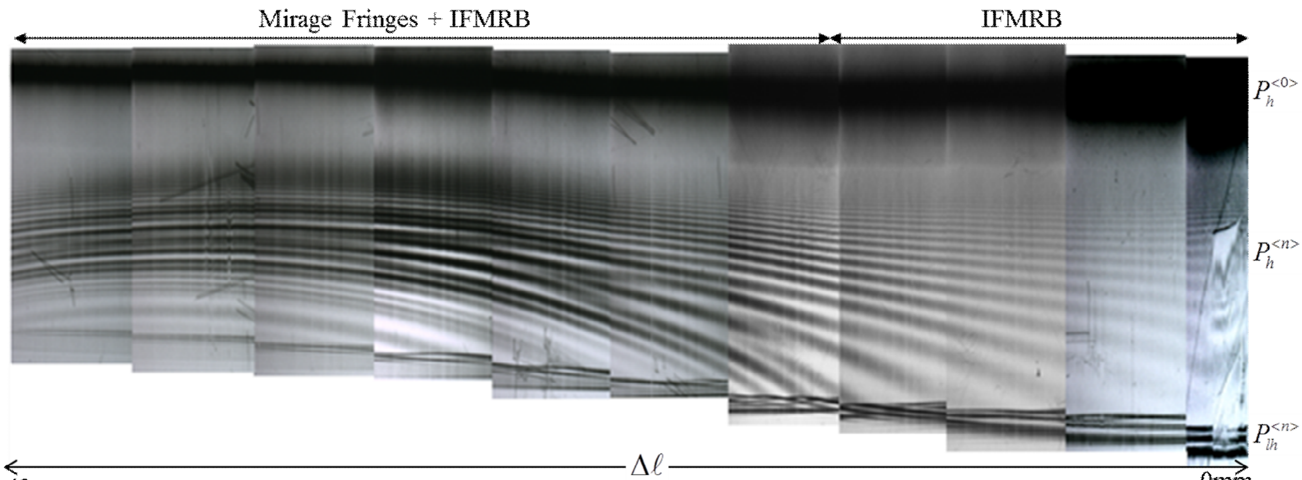

Fig. 2. Section topographies of Si 220 between the clamped (left) and the free ends (right). $\Delta\ell$ =0 - 42 mm.