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Deformation of X-Ray Mirage Fringes by Strain due to Crack

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We previously observed interference fringes between mirage diffraction beam and the reflected beam from the bottom surface (IFMRB) when the crystal is very weakly bent [1,2]. The fringe spacing of IFMRB becomes large as the distance between the incident point and the emitted point of the beam increases.

We have observed that IFMRB are deformed by strain around a crack near the surface of a weakly bent Si crystal. Figure 1 shows a schematic illustration of the beam trajectories of X-rays. The crystal thickness is 0.28 mm. x_1 is the distance from the incident point to a crack and x_2 that from the crack to the position of deformed IFMRB by the strain. The distance from the crack to the crystal edge is 5.5 mm.

The experiments were carried out using X-rays from synchrotron radiation at the bending magnet line BL-15C, KEK-PF. Figure 2 shows reflected section topographies of Si 220 observed by changing x_1. We can see a dark line due to the crack whose width is approximately 50 μm as indicated by the solid arrow above each figure. IFLSD stand for interference fringes observed in the beam emitted from the lateral surface in the diffracted beam direction and are also deformed by the crack. In Figs. 2(a), (b) and (c), x_1 is 0.8, 1.8 and 3.0 mm, respectively. In Fig 2(a), a V-shaped pattern with modulations is observed around x_2=2.6 mm as indicated by the white arrow. In Fig. 2(b), IFMRB are deformed and the contrast is enhanced around $x_2=|x_1|$ as indicated by the white arrow. In Fig. 2(c), both a V-shaped pattern (the downward white arrow) and deformed and enhanced IFMRB around $x_2=|x_1|$ (the white upward arrow) are observed. According to fracture mechanics, the closer to the top of a crack or the larger the depth of the crack, the larger the strain due to the crack, which explains the V-shaped pattern of IFMRB in Fig. 2(a). The white V-shaped contrast in Fig. 2(c) is explained by the fact that the beam reflected from the bottom surface is blocked by the crack as depicted in the upper part of the figure.

In Fig. 1, if we regard the reflected beam from the bottom surface as the reference beam and the mirage diffraction beam as the object beam, we can produce a hologram of the crack by using the deformed IFMRB. It is noted that the hologram of IFMRB should be useful to investigate the strain distribution around the crack. Since the deformed and enhanced IFMRB in Figs. 2(b) and 2(c) are caused as a result of focusing effect of the mirage diffraction beam due to the crack, it will be possible to control the trajectory of mirage diffraction beam by making a crack of different shape.

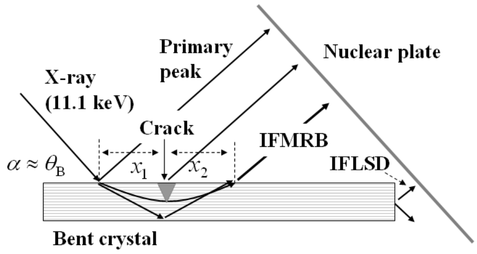

Fig. 1: Beam trajectories in a weakly bent crystal when the strain gradient is positive.

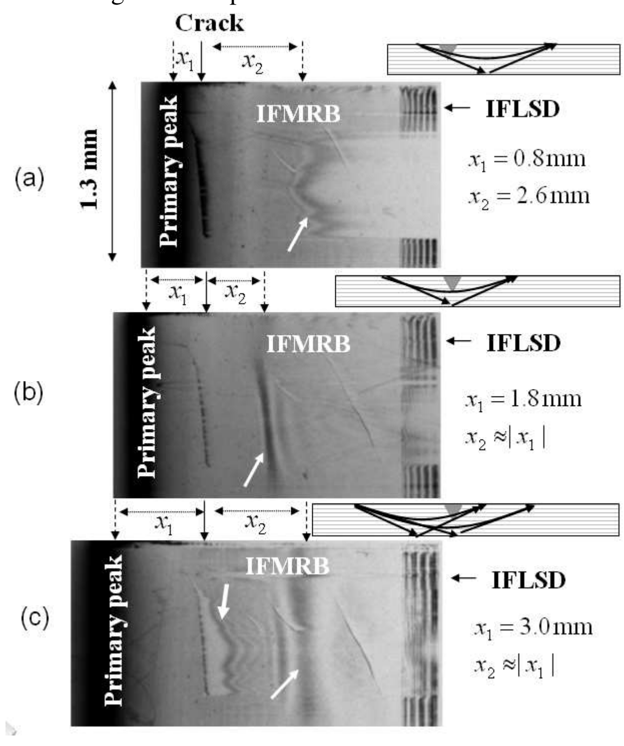

Fig. 2: Section topographies of Si 220 observed by changing x_1.

References
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