Crystallography

15C/2002G046

Observation of X-ray Topographs with Ensemble Effect

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The rocking curve with only Thomson scattering in the Bragg case shows a wide total reflection region around the exact Bragg angle. In the total reflection region, the attenuation of the Electric field becomes extremely strong (extinction effect) and only atoms within the distance of several microns (extinction distance) under the crystal surface contribute to the reflection. On the other hand, the rocking curve only by the imaginary part f'' of anomalous scattering factor becomes very sharp with total reflection just at the Bragg angle. At this condition of the total reflection, the attenuation vanishes (Borrmann effect[1)]), and all the atoms in the crystal contribute to the reflection. This is called as an ensemble effect[2)] known as the suppression effect of the incoherent channel in the nuclear resonant scattering. At room temperature, the attenuation exists due to thermal vibration, but the diffraction induced only by f'' can be obtained and the ensemble effect is still expected. We report on the observed results of X-ray topography of Ge 844 reflection under such condition.

The experiment was performed in KEK-PF BL-15C. The optical system is shown in Fig.1. The specimen thickness is 82μm. The selected energy of the incident X-rays is (I)-100eV and (II)-3eV from the K-absorption edge(ω_k) of Ge. The condition (I) corresponds to one that the extinction effect is dominant, and (II) corresponds to one that the ensemble effect is expected.

Fig.2 (1) and (2) are topographs taken under the conditions of (I) and (II), respectively. In Fig.2, (a) is the diffracted image and (b) the transmitted image. The darker contrast corresponds to the higher intensity of X-rays. In Fig.2 (1), the lateral contrasts in (a) and (b) marked by arrow A are obtained from the same defect region. The former is bright, and the latter is dark. This suggests that the extinction effect is smeared out by the distorted lattices.

The defect region marked by arrow A in Fig.2(1)-(a) is clear and narrow and that in (2)-(a) is dim and wide. Furthermore, the dark defect contrast marked by arrow B in Fig.2(1)-(b) shows bright contrast similar to that in Fig.2(2)-(a), but the contrast cannot be seen in Fig.2(1)-(a). It is understood that the defects deep under the crystal surface (see the contrast marked by arrow B in Fig.2(1)-(b)) can still be observed in the diffracted-image using the ensemble effect (see the contrast marked by arrow B in Fig.2(2)-(a)), though they cannot be seen in Fig.2(1)-(a).

In addition, the defect contrasts observed in (1)-(a), (1)-(b) and (2)-(a) cannot be observed in (2)-(b) at all. This may be related to the ensemble effect, which will be a future work.

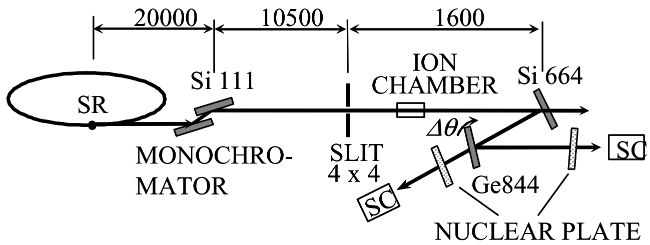

Fig 1. Optical system

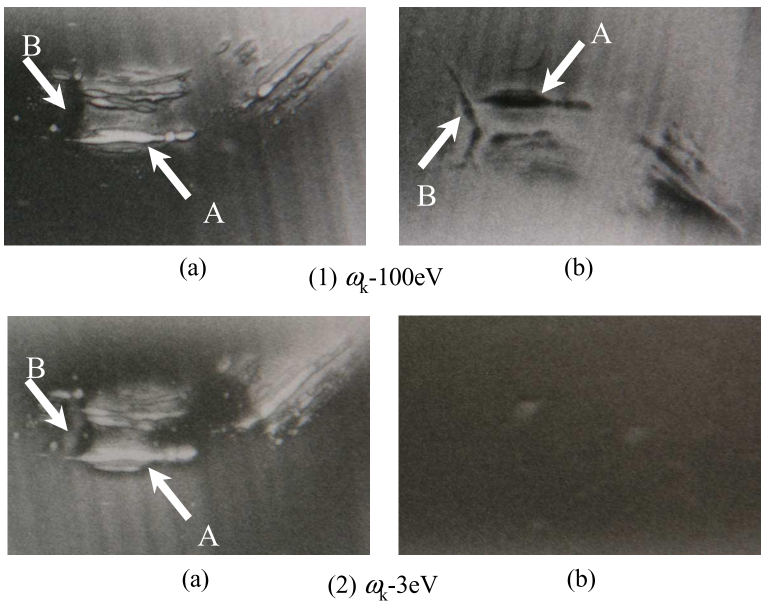

Fig 2. Observated topographs

1) T. Fukamachi, et al, Acta Cryst. A58, 552(2002).
2) G. Materlik, C. J. Sparks and K. Fischer ed.: Resonant Anomalous X-ray Scattering, (Noth-Holland, Amsterdam) (1994)

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