Determination of Strain Gradient of Bent Crystal by Measuring Rocking Curves II

Tomoe FUKAMACHI1, Sukswat JONGSUKSWAT1, Dongying JU1, Riichirou NEGISHI1, Keiichi HIRANO2, and Takaaki KAWAMURA3

1Saitama Institute of Technology, Fukaya, Saitama 369-0293, Japan
2Institute of Material Structure Science, KEK-PF, High Energy Accelerator Research Organization, Oho, Tsukuba, Ibaraki 305-0801, Japan
3University of Yamanashi, Kofu, Yamanashi 400-8510, Japan

1 Introduction

It is pointed out that the angle difference $\Delta \alpha$ in the peak positions between the diffracted ($P_h$) and transmitted ($P_t$) beams from a bent crystal increases as the strain gradient $\beta$ increases in a previous report [1]. Based on this, we report on the determination of $\beta$ by measuring $\Delta \alpha$.

The experiments were carried out using X-rays from synchrotron radiation at BL-15C, PF, KEK. The sample geometry, a schematic diagram of the optical system, and the observed rocking curves were shown in ref. [1].

Under anomalous transmission condition the X-ray refracted beam propagates along a hyperbolic trajectory in a bent crystal. The distance of the vertex of the hyperbola from the surface $z_v$ is given by

$$z_v = \tan \theta_h (W+1)/\beta. \quad (1)$$

Here $W = \sin 2\theta_h /|\chi_h|$ is the resonance error, $\chi_h$ the $h$th Fourier component of the X-ray polarizability and $\Delta \alpha$ the angle deviation from the centre of $P_h$ as shown in Fig. 1(b). When the refracted beam comes in contact with the bottom surface, the resonance error $W$ satisfies eq.(1) with $z_v = H$ (the crystal thickness). In Fig. 1(a), the beam satisfying $|W| < |W_v|$ is reflected as a mirage diffraction beam ($P_m$) and that satisfying $|W| > |W_v|$ is transmitted from the bottom. The rocking curves of $P_h$, $P_t$ and $P_m$ are shown in Fig. 1(b). $\Delta \alpha_h$ is the angle difference between the peaks of $P_h$ for $\beta \neq 0$ and for $\beta = 0$. By measuring $\Delta \alpha_h$, the value of $\beta$ is obtained using the relation

$$\beta = 2 \Delta \alpha_h \sin \theta_h /|\chi_h| H. \quad (2)$$

![Fig. 1: Schematic illustration of beam trajectories (a) and rocking curves of $P_h$, $P_t$, and $P_m$ obtained from Fig. 6 of ref. [2] (b).](image)

2 Results and Discussion

Table 1 shows the results of measured $\Delta \alpha_h$ and $\beta$ determined by using eq. (2) for Si 220 as a function of the displacement $D$ at the free end of the crystal whose other end is clamped [1]. Fig. 2 shows the plots of these $\beta$ as a function of $D$ together with those determined by using interference fringes between two mirage diffraction beams (IFMD) [3]. The values of $\beta$ determined by the two methods show excellent agreement. When $\beta$ becomes large, the period of IFMD becomes small, which makes it difficult to measure the period to determine $\beta$. The maximum value of $\beta$ to be obtainable by using IFMD is approximately 3 mm$^{-1}$. In contrast, it becomes easier to measure $\Delta \alpha_h$ and to obtain $\beta$ when $\beta$ becomes larger in the present method. These two methods are complementary to each other.

![Fig. 2: Relation between $D$ and $\beta$. Solid circles show the present results and diamonds those by IFMD [1].](image)

Table 1: The values $\Delta \alpha_h$ and $\beta$ as a function of $D.$

<table>
<thead>
<tr>
<th>$D$ (µm)</th>
<th>$\Delta \alpha_h$ (°)</th>
<th>$\beta$ (mm$^{-1}$)</th>
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<tr>
<td>12.5</td>
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References


* tomoe-f@wonder.ocn.ne.jp