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

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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 β increases in a previous report [1]. Based on this, we report on the determination of β 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_a is given by

$$z_a = -\tan\theta_B (W+1)/\beta. \quad (1)$$

Here $W = (\sin 2\theta_B / |\chi_h|)\Delta\alpha$ is the resonance error, χ_h the hth 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_c satisfies eq.(1) with $z_a = H$ (the crystal thickness). In Fig. 1(a), the beam satisfying $|W|<|W_c|$ is reflected as a mirage diffraction beam (P_m) and that satisfying $|W|>|W_c|$ is transmitted from the bottom. The rocking curves of P_h, P_t and P_m are shown in Fig. 1(b). $\Delta\alpha_s$ is the angle difference between the peaks of P_t for $\beta \neq 0$ and for $\beta = 0$. By measuring $\Delta\alpha_s$, the value of β is obtained using the relation

$$\beta = 2\Delta\alpha_s \sin^2\theta_B / (|\chi_h| H). \quad (2)$$

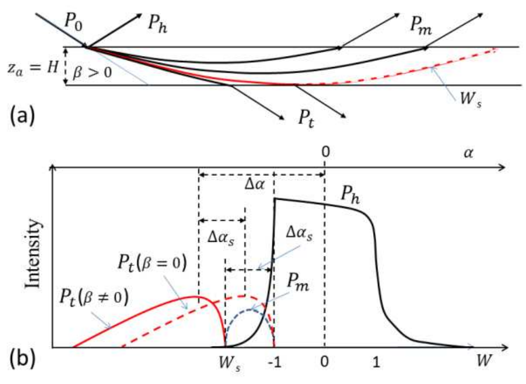

Fig. 1: Schematic illustration of beam trajectories (a) and rocking curves of P_h, P_t and P_m obtained from Fig. 6 of ref. [2] (b).

2 Results and Discussion

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

Table 1: The values $\Delta\alpha_s$ and β as a function of D.

D (μm)	$\Delta\alpha_s$ (")	β (mm^{-1})
12.5	0.5	0.31
17.5	0.75	0.46
22.5	1	0.62
27.5	1.5	0.93
32.5	1.75	1.1

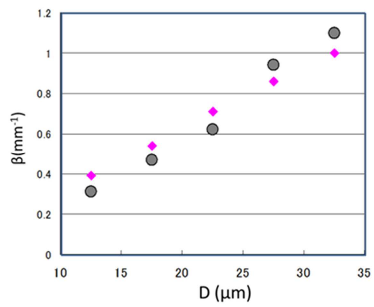

Fig. 2: Relation between D and β. Solid circles show the present results and diamonds those by IFMD [1].

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