Determination of Strain Gradient of Bent Crystal by Measuring Rocking Curves

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We report on the determination of strain gradient $\beta$ of a Si bent crystal by measuring the angle difference $\Delta \theta$ from the peak of the diffracted beam ($P_h$) to that of the transmitted beam ($P_c$) in the Bragg mode.

The experiments were carried out using X-rays from synchrotron radiation at the bending magnet beam line BL-15C, Photon Factory, KEK. The optical system is shown in Fig.1 (b). The X-rays were $\sigma$-polarized and the energy was tuned at 11100 eV. After Slit 1, the first crystal was set as a collimator. The Si plane parallel crystal (50 mm long, 15 mm wide and 0.28 mm thick) was bent with displacement $D$ at one end and the other end fixed as shown in Fig. 1(a). The beams $P_h$ and $P_c$ were measured by the scintillation counters (SC1 and SC2). The interference fringes of mirage diffraction (IFMD) were measured by moving Slit 3 in front of SC1.

Fig. 1: (a) Geometry of sample and X-ray. (b) Schematic diagram of the optical system with double crystal diffractometer in (+,−) configuration.

The rocking curves of $P_h$, $P_c$, and IFMD were measured for various $D$. Fig. 2(a) shows the measured IFMD for three values of $D$. $x$ is the distance from the incident point to the emitted point of the beam. The spacing of IFMD becomes small as $D$ increases. $\beta$ was determined by measuring IFMD according to ref. [1]. $\beta$ linearly increases as $D$ increases (Fig. 2(b)). Fig. 3(a) shows the measured rocking curves of $P_h$, $P_c$ and $R_c$ for the same values of $D$. $\Delta \theta$ increases as $D$ increases (inset table of Fig. 3(b)).

The mirage diffraction beam is excited at the angle outside the total reflection region in a bent crystal. When it is excited, the corresponding refracted beam does not cause the transmitted beam as shown in Fig. 1(b). If $D$ increases, the angle width of the mirage diffraction beam becomes large and $\Delta \theta$ becomes large, as the mirage diffraction is observed between $P_h$ and $P_c$.

The measurement of rocking curves should be very useful for determination of the strain gradient, as the measurement is easier than that of IFMD.

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Fig. 2: (a) Intensities of IFMD and IFLSD (interference fringes in the beam emitted from the lateral surface) as a function $x \sin \theta_B$. (b) Relation between $D$ and $\beta$.

Fig. 3: (a) Measured rocking curves of $P_h$ and $P_c$ of Si 220. (b) Values of $\beta$ and $\Delta \theta$ in $P_h$ as a function of $D$.

References

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