Improvement of sensitivity for detecting strains in silicon using highly collimated x-rays

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Imperfection of silicon single crystals is critical for silicon devices because it degrades their electrical characteristics. X-ray topography is often used to non-destructively detect strain fields showing the imperfection. We had previously observed macro- and microscopic images of strain fields in silicon using highly collimated x-rays at the Photon Factory[1)]. In this experiment we aimed at the improvement of strain sensitivity using higher-order reflection.

At first, the same x-ray optics as used in the previous experiment was applied at the beamline BL09XU to perform rocking curve measurements. A wavelength of x-rays was tuned to 0.072 nm by a double-crystal silicon monochromator with the rotating inclined geometry using 111 reflections. A highly collimated x-ray beam was obtained using successive asymmetric 220 reflections of the silicon collimator system with an asymmetric factor of 1/60. Using this x-ray beam, rocking curves of the 220 reflection from a 0.3-mm-thick MCZ silicon crystal were measured in the Laue geometry. The experimental curve clearly showed an oscillatory profile and was in good agreement with the theoretical curve [see Fig. 1].

Higher collimation of the incident x-ray beam was realized using successive 440 reflections of the collimator system with an asymmetric factor of 1/32. A rocking curve of 440 reflection from the 0.3-mm-thick silicon crystal measured in the Laue geometry is shown in Fig. 2. The amplitude of the oscillation of the experimental curve is largely degraded in comparison with the theoretical curve. The degradation is considered to be caused by a very slight bend of the sample.

Local angular deviations from the Bragg condition caused by strains can be detected using the intensity change in the oscillatory profile of rocking curves. Therefore, the x-ray optics using the successive 440 asymmetric reflections is more sensitive to strains than the previous optics. The higher collimation of an x-ray beam will also lead to higher strain-sensitive x-ray diffraction topography.

1) S. Kawado, S. Kojima, I. Maekawa and T. Ishikawa, Appl. Phys. Lett. **58** (1991) 2246.

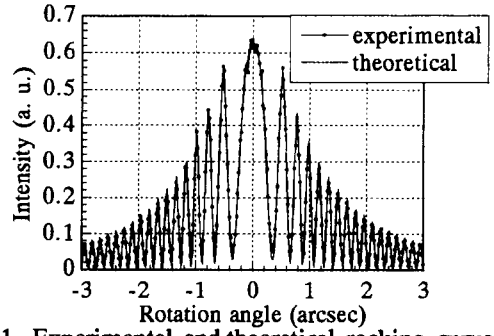

Fig. 1. Experimental and theoretical rocking curves in the optics using successive 220 asymmetric reflections.

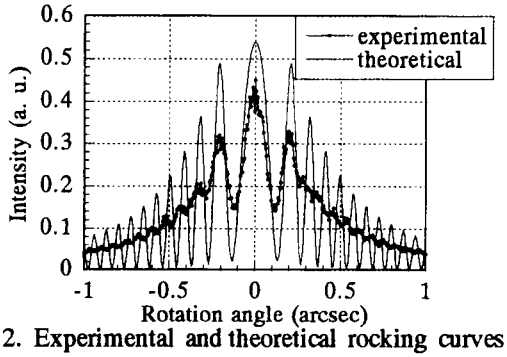

Fig. 2. Experimental and theoretical rocking curves in the optics using successive 440 asymmetric reflections.