One dimensional expansion of phase contrast image from micro-stripe patterns

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Phase-contrast image from micro-stripe patterns was successfully expanded one-dimensionally by use of asymmetric Bragg reflection. This technique is available for observation of submicron patterns fabricated in Si wafers.

Experiments and Results

X-rays were tuned to an energy of 15keV by the double-crystal monochromator at the BL24XU-C. The incident X-ray beam size was $1\times1mm^2$. The refracted X-ray beam from the sample pattern was expanded horizontally by use of (531) asymmetric reflection twice with two Si (110) crystals which were located at the rear of the sample with (+, -) arrangements. Since the angle, α, between the crystal surface and diffraction plane is 17°, the asymmetric factor b is estimated to be about 1/5. Thus, the refracted beam is expanded horizontally into 25 times. The refracted beam divergence ($10^{-5}\sim10^{-6}$ radians) is small enough for all the refracted beam to be subjected to Bragg reflection on the Si(110) crystals.

The ray-trace (Fig.1) illustrates how arise the highlight and dark bands. Figure 2 shows a series of recorded intensity distributions on a film at several incident beam angles θ. Phase-contrast profile can be extracted from the recorded intensity distribution by subtracting absorption-contrast profile. The gap-depth fabricated in the pattern was successfully evaluated by the relation of the distance between the highlight and dark bands to the incident angle.

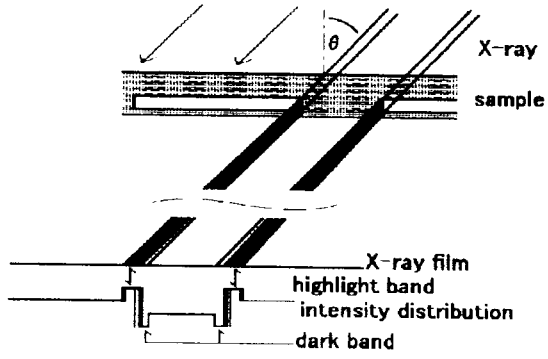

Fig.1

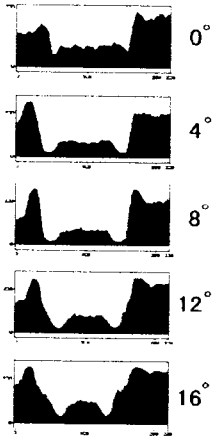

Fig.2