Precise X-ray Diffraction Measurements using Hard X-ray Microbeam Formed by Asymmetric Diffraction

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Production of highly parallel x-ray microbeam by using asymmetric diffraction has been tried on BL24XU. In the present work, we succeed to produce hard x-ray microbeam with a size of 7.1 μm (horizontal) × 4.7 μm (vertical), an angular divergence of 7.7 μrad and an energy band width of 57meV.

Two-dimensional condensation has been realized by using two sets of two asymmetric 115 diffraction as shown in Fig. 1. X-rays with an energy of 15 keV were selected with a double-crystal monochromator using flat Si(111) crystals. After reducing the size of the x-rays to 100 μm (horizontal) × 50 μm (vertical) with two slits, the x-rays condensed by four Si(001) crystals using 115 asymmetric diffraction. The first two crystals condensed the beam in the horizontal direction, and second two in the vertical direction. Since the magnification factor M of the 115 asymmetric diffraction is about 0.21, the beam size was reduced both horizontally and vertically with magnification of $M^2 = 0.044$. If the condensed beam has no divergence, the size at the sample position is estimated to be about 4.4 μm × 2.2 μm. Due to the beam divergence, however, actual size was about 7.1 μm × 4.7 μm.

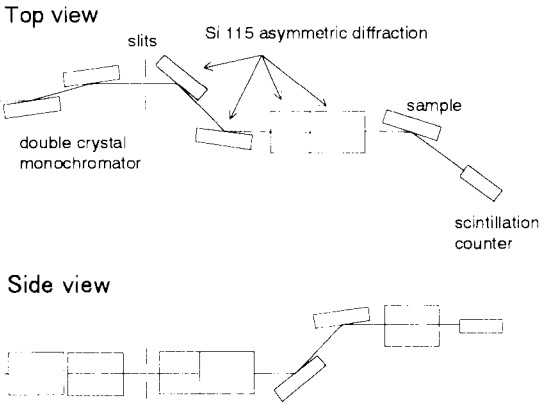

Fig. 1 Schematic diagram of the experimental arrangement.

Using this x-ray microbeam, we measured the strain induced by field oxidation in silicon wafers. 004 diffraction profiles were measured for near field oxide edge. Figure 2 shows a contour map of the diffraction intensity for the distance from the field oxide edge. We could detect a maximum compressive strain of 5.0×10^{-6} at a point of 5 μm silicon side from the field oxide edge and a maximum tensile strain of 6.9×10^{-6} at a point of 5 μm oxide side. Thus, this technique is very useful for non-destructive determination of local minute strain with $\Delta d/d$ less than 1×10^{-5}.

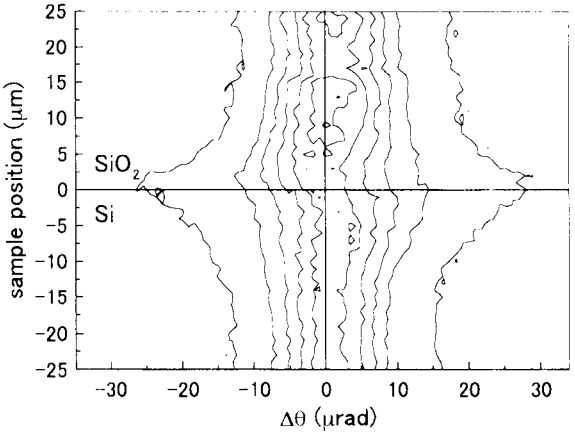

Fig. 2 A contour map of the 004 diffraction intensity for the distance from the field oxide edge.