Submicron-Resolution X-ray Topography Using Fresnel-Zone-Plate Magnification

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We have developed an image magnification method using a Fresnel zone plate (FZP) to obtain submicron resolution in X-ray diffraction and topography [1, 2]. This paper describes the FZP method for local strain analysis of microstructure-fabricated silicon materials.

The experiments were performed at BL16XU in SPring-8. The FZP was a phase modulation type, whose zone structure was made of a 2-micron-thick Ta layer on a 2-micron-thick SiN membrane. The diameter was 22 microns, and the width of the outermost zone was 0.2 micron. The experimental setup is shown in Fig. 1. Si-400 reflection was used at a photon energy of 8.5keV (Si-111 monochromatized), at which the focal length of the FZP was 31mm. The diffracted X-ray image was expanded 27 times by the FZP (50mm from the sample) and focused on a slit (900mm from the FZP), through which the X-ray intensity was measured. The slit aperture was located at a 200-micron-offaxial position to avoid the zeroth-order direct beam.

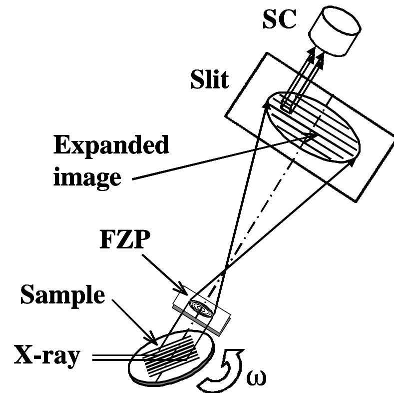

Fig.1. Experimental set-up

The sample used was a Si{100} wafer upon which an oxide pattern was fabricated (Fig. 2A, 2B). The topograph shown in Fig.2C was obtained by moving the sample in two dimensions. The lines of high X-ray intensity, which correspond to the regions between the oxide stripes, represent surface damage caused by etching the oxide. Figure 2D shows the contour map of rocking curves obtained at intervals of 0.25 micron along $Y = 0$. The peak positions ω_P of the rocking curves were estimated by parabola fitting (Fig. 2E). The variation of ω_P corresponds to $\Delta d/d \sim \pm 1 \times 10^{-5}$, indicating that tensile strains were caused under the oxide layers. The spatial resolution was estimated to be less than 0.5 micron.

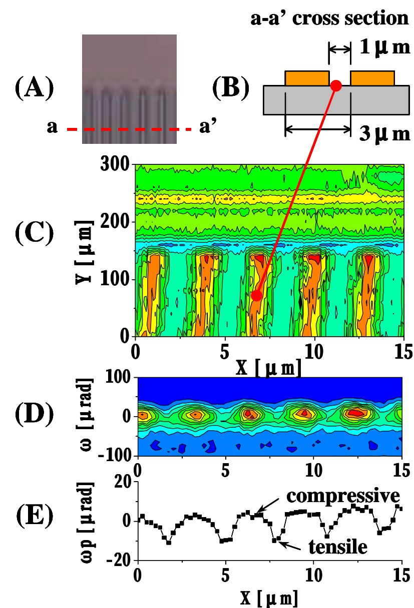

Fig.2. Strain analysis of an oxide-patterned silicon wafer

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[1] Ext. Abstracts of the 63rd Autumn Meeting, JSAP, 24p-T-7 (2002)
[2] Ext. Abstracts of the 64th Autumn Meeting, JSAP, 30a-ZK-3 (2003)