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Observation of two-dimensional distribution of lattice inclination and strain in strained Si wafers by synchrotron x-ray topography

Takayoshi SHIMURA*[1], Tomoyuki INOUE[1], Daisuke SHIMOKAWA[1], Takuji HOSOI[1], Heiji WATANABE[1], Atsushi OGURA[2] and Masataka UMENO[3]
[1]Graduate School of Engineering, Osaka University, 2-1 Yamadaoka, Suit, Osaka 565-0871, Japan
[2]School of Science and Technology, Meiji University, 1-1-1 Higashimita, Kawasaki 214-8571, Japan
[3]Dept. of Management Info. Sci., Fukui Univ. of Tech., 3-6-1 Gakuen, Fukui 910-8585, Japan

Strained Si technology has attracted substantial attention as a means of enhancing carrier mobility in metal-oxide-semiconductor field-effect transistors (MOSFETs) and thereby extends the limits of device miniaturization and performance. One of the methods available for the fabrication of strained Si devices involves the use of strained Si wafers, which have a surface layer of strained Si with a typical thickness of 20 nm. This approach to fabrication is advantageous in that relatively large strain can be achieved using conventional device fabrication processes. However, the crystalline quality of the strained Si wafers fabricated to date remains poor compared to conventional SOI wafers. It is therefore important to evaluate the crystalline quality of the strained Si wafers in order to continue improving this technology.

Synchrotron radiation (SR) x-ray topography is an effective technique for characterizing imperfections in crystalline thin films, yielding a two-dimensional distribution of atomic-level structural information [1-3]. It represents valuable information for achieving an accurate understanding of the crystalline quality of wafers and for improving wafer fabrication techniques. In this study we demonstrate two-dimensional distributions of lattice inclination and strain in strained Si wafers obtained by synchrotron x-ray topography.

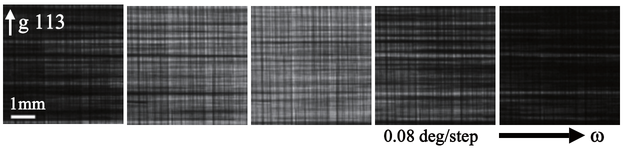

Fig 1. X-ray topographs obtained by changing the incident angle

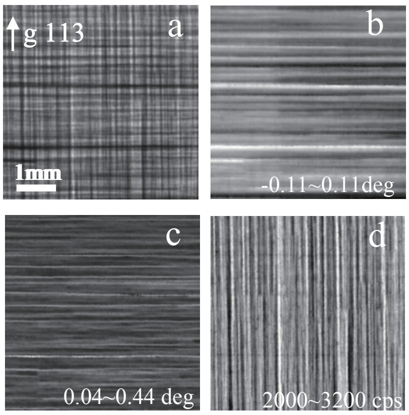

Fig 2. (a) shows x-ray topograph. (b)~(c) show the distributions of peak position, FWHM, and integrated intensity of rocking curve at each pixel of CCD detector, respectively.

Fig. 1 shows a series of x-ray topographs of supercritical-thickness strained Si on insulator (SC-sSOI) wafer obtained by changing the incident angle and they show clear crosshatch pattern. Fig. 2 shows the distributions of peak position, FWHM, and integrated intensity derived from the rocking curve at each pixel of CCD detector. They are no longer crosshatch, but line patters. This is because the crosshatch pattern is mainly due to the lattice undulation. Fig.3 (a) and (b) show the distributions of lattice undulation and lattice strain, respectively, which were estimated by comparing the distributions of peak position obtained using x-ray topographs of 113 and -1-13 reflections. The fluctuation of strain was estimated to be less than 0.02%. Fig. 3 (c) shows the distribution of the lattice undulation in the [1-10] direction obtained through the same procedure. Fig. 3 (d) shows the morphology of the lattice plain, which was obtained by numerical integration of the distributions of lattice undulation in two directions, Fig. 3 (a) and (c).

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*shimura@mls.eng.osaka-u.ac.jp

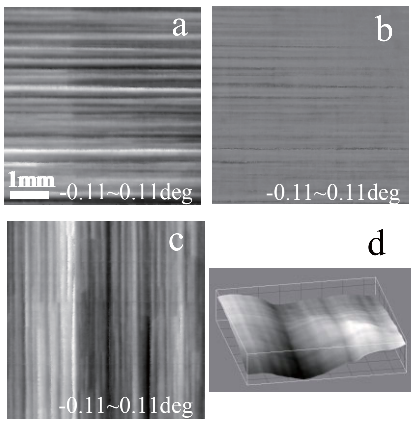

Fig. 3 (a), (c) and (d) show the distributions of lattice inclination and the morphology of lattice plane, respectively. (b) shows the distribution of lattice strain.