2004A0496-NXb -np BL47XU

X-ray Fluorescence Microscope and Micro-Tomography by Scanning a Zone Plate

Norio WATANABE[1) ※] (3265), Takuji OHIGASHI[1)] (4010), Mariko SATO[1)] (14419), Masato HOSHINO[1)] (9987), Sadao AOKI[1)] (3277), Akihisa TAKEUCHI[2)] (1716), Yoshio SUZUKI[2)] (1177),

[1)] Institute of Applied Physics, University of Tsukuba, Tsukuba, Ibaraki 305-8573, Japan

[2)] SPring-8, JASRI, Mikazuki, Hyogo 679-5198, Japan

Several hard x-ray scanning microscopes had been successfully developed at synchrotron radiation facilities. In these microscopes, a specimen was usually raster scanned with the stationary microprobe. For tomographic application, it is necessary to scan a rotary stage mounting a specimen with the accuracy better than the resolution of the microscope. It is difficult because a precision rotary stage is usually large and heavy. Then, another scanning microscope by scanning a microprobe instead of a specimen was developed.

Figure 1 shows the optical system of the microscope. Monochromatic x-rays at 9.8 keV were focused onto a specimen by a zone plate (outermost zone width 0.1 μm, diameter: 155 μm). The first order focus was used and the other order x-rays were eliminated by an order sorting aperture (OSA, diameter: 20 μm). The zone plate was mounted on a 2D piezoelectric stage of which the maximum scan size was 80 × 80 μm^2. It was smaller than the x-ray beam size at the zone plate. The zone plate and the OSA were raster scanned synchronously to obtain a 2D image. Transmission and fluorescence x-rays were recorded by an ionization chamber and silicon drift detector (SDD) respectively.

Figure 2 shows an x-ray transmission image of a tantalum pattern of 0.5 μm in thickness (0.2 μm line and 0.2 μm space). Suppose a Gaussian distribution of the microprobe, the vertical and horizontal size was estimated at 0.28 μm and 0.40 μm from the image contrast.

.Figure 3 shows reconstructed section images of a test specimen. The specimen consisted of iron, zinc, and copper evaporated on a glass capillary. These elements could be reconstructed, but these could not be distinguished in this experiment. It was mainly due to the lack of resolution and the vibration of the specimen during the exposure.

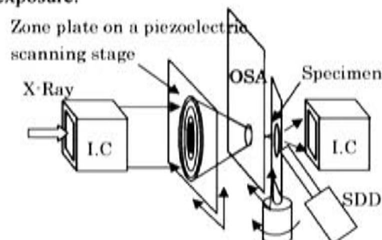

Fig. 1 Optical system of the microscope

Fig. 2 X-ray image of a tantalum line pattern. The line and space widths are 0.2 μm. Exposure: 0.1 s/pixel.

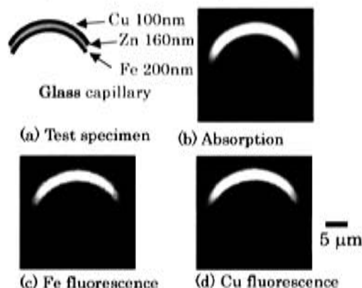

Fig. 3 X-ray fluorescence tomography of a test specimen.

2004A0563-NSa-np-Na BL47XU

Depth Profiling of High K Dielectrics/Si(100) Interfacial Transition Layer

H. Fujita(14379)[1], T. Hattori* (07880)[1], E. Ikenaga(00448)[2], K. Kobayashi(01835)[2], H. Nohira(08035)[1], H. Okamoto(13619)[1], S. Shinagawa(13618)[1], Y. Takata(01866)[3], and T. Yoshida(09213)[1]

[1]Department of Electrical & Electronic Engineering, Musashi Institute of Technology

[2]Japan Synchrotron Radiation Research Institute

[3]Soft X-ray Spectroscopy Laboratory, Harima Institute, RIKEN

La_2O_3 have been studied extensively as an alternative to silicon oxide in the future generation of MOSFETs. In general the lanthanum silicate layer is inevitably formed between lanthanum oxide and Si substrate as a transition layer. The SiO_2/Si interfacial transition layer is also formed between this silicate layer and Si substrate. Because the interface state density and the carrier transport in channel region are seriously affected by the structure of these transition layers (abbreviated as TLs hereafter), it is important to determine the chemical structure of these TLs in the depth direction. However, in our previous study we could not determine the chemical structures of these TLs because Si 2p core level have almost the same binding energy with La 3d core level and we inevitably used Si 2s spectra, whose full width at half maximum(FWHM) is not small enough for the determination of the chemical structures of these TLs. Hard X-ray (5.9534 keV photons) photoelectron spectroscopy system newly developed at BL47XU enabled us to detect Si 1s spectra with enough energy resolution. The atomic-scale depth profile of the chemical structures of these TLs can be easily determined by analyzing angle-resolved photoelectron spectra based on high resolution Rutherford backscattering spectra measured by Prof. Kimura's group at Kyoto Univ.

Approximately 4-nm-thick lanthanum oxide films were deposited on Si(100) substrate at room temperature by electron beam evaporation of La_2O_3 and subsequently annealed in nitrogen atmosphere under atmospheric pressure at 300°C, 400°C and 500°C. La 3d, Si 1s and O1s spectra arising from these films were measured at photoelectron take-off angle of 8, 15, 30, 40, 55 and 80 degrees using high resolution electron energy analyzer ESCA-2002.

Figure 1 shows Si 1s spectra measured at photoelectron take-off angle of 50 degrees with annealing temperature as a parameter. The chemical structure of the TL between La_2O_3 and Si substrate formed by annealing at 300°C are shown and consist of Si^{4+}, Si^{3+}, Si^{1+} in addition to Si^{X+}, which is considered to arise from lanthanum silicate. As can be seen in this figure, the amount of lanthanum silicate increases by increasing the annealing temperature from 300°C to 400°C and 500°C. The total amount of intermediate oxidation states consisting of Si^{1+} and Si^{3+} was found to be 3.23×10^{18} m^{-2}, which implies the abrupt compositional transition at SiO_2/Si interface. Dependence of FWHM of Si 1s spectrum arising from Si substrate on photoelectron take-off angle implies the formation of Si-La bonds near the interface.

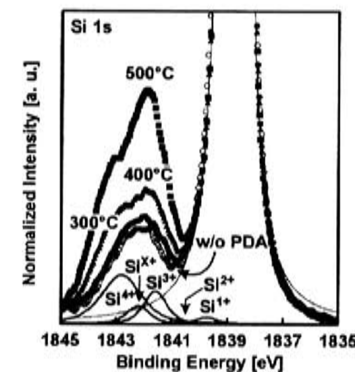

Fig. 1 Si 1s spectra from interfacial transition layer with annealing temperature as a parameter.