Depth Profiling of Gate Dielectrics/Si Interfacial Transition Layer

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La_2O_3 have been studied extensively as an alternative to silicon oxide in the future The electron escape depth in silicon oxide layer and that in silicon used for the determination of silicon oxide thickness by X-ray photoelectron spectroscopy have been determined by considering that the number of X-ray excited photoelectrons in silicon oxide layer and that in silicon decrease before escaping into vacuum as a result of inelastic scattering of electrons in silicon oxide layer. However, such method cannot be applied to the oxide layer with the thickness on the order of 1 nm. In the present paper the method of determining the electron escape depths in ultrathin silicon oxide layers by layers by measuring angle-resolved Si 2p photoelectron spectra is proposed and the electron escapes in low-temperature oxides formed at 300°C using atomic oxygen are found to be clearly different from that in high-temperature oxide formed at 900°C using molecular oxygen.

Three kinds of approximately 1-nm-thick low-temperature silicon oxide layers, that is, 0.70 nm-thick-oxide-layer formed in microwave (2.45 GHz) excited krypton-mixed oxygen($Kr:O_2 = 97:3$) plasma at 300°C (abbreviated as Kr/O_2 plasma oxide hereafter), 0.57-nm-thick-oxide-layer formed in microwave(2.45 GHz) excited oxygen plasma at 300°C (abbreviated as O_2 plasma oxide hereafter) and 0.66-nm-thick-oxide-layer formed in atomic oxygen excited by xenon excimer lamp at 300°C (abbreviated as photo oxide hereafter) were formed on epitaxially grown vicinal Si(100) 0.01° at 300°C. As a reference a high quality 0.70-nm-thick oxide layer was formed in dry oxygen at 900°C on Si(100) surface through 0.3-nm-thick preoxide formed in dry oxygen at 300°C (abbreviated as thermal oxide hereafter). Using electron energy analyzer ESCA-200 angle-resolved 1050 eV photons' excited Si 2p photoelectron spectra and 714 eV photons' excited O 1s photoelectron energy loss spectra were measured with energy resolution of 100 meV.

The dependences of NI/NO on θ measured for three kinds of oxide layers formed on Si(100) are compared with that measured for thermal oxide in Fig. 1. The solid curves in Fig. 1 are calculated by considering that the electron escape depths in three kinds of low temperature oxides are in the range from 2.2 to 2.3 nm, while that in thermal oxide is 2.7 nm. The value of 2.7 nm is slightly smaller than the value of 2.85 nm, which was determined for the bulk SiO_2 from the escape depth(3.80 nm) of Si 2p photoelectrons in SiO_2 excited by Al Kα radiation by considering the dependence of electron escape depth on kinetic energy of electrons.

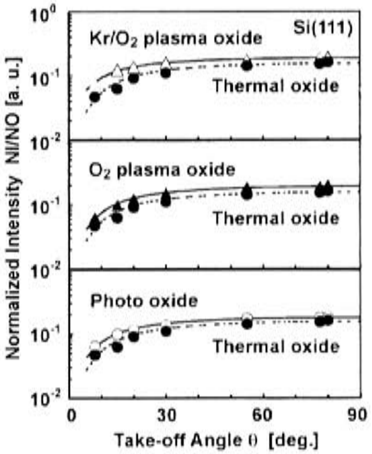

Fig. 1 Dependence of NI/NO on θ for Kr/O_2 plasma oxide, O_2 plasma oxide and photo-oxide. As a reference dependence of NI/NO on θ for thermal oxide is also shown.

Development and Evaluation of Quarter-wave Plates for High Energy Soft X-ray by Using Linearly Polarized SR Emitted from the Figure-8 Undulator

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A full polarization state can be obtained by using a phase shifter and a polarizer. A quarter-wave plate, which is a phase shifter having retardation of 90°, is especially desired for accurate determination of the full polarization measurement for highly circularly polarized light.

Transmitting Sc/Cr multilayers were designed and developed as a quarter-wave plate of 398.6eV. We measured polarization properties, such as retardation and polarizance $((T_S - T_P)/(T_S + T_P))$, of four Sc/Cr multilayers at BL27SU. All of the four has same design (periodicity d=3.15nm, dCr/d=0.47, 300 periods) but made in different time. The degree of linear polarization of the probe beam was measured to be over 0.99. The effects of non-linearly polarized components on the measurements were taken into account. The divergence of the probe beam was estimated to be 1.8 mrad.

Table 1 shows polarization properties of the Sc/Cr multilayers. The polarization properties were different from each other. The results indicated #2 works as the best quarter-wave plate, because the polarizance) at the incident angle, where the retardation was 90degrees, was smallest.

The retardation and polarizance of the multilayers are sensitive to roughness of the interface between Sc and Cr layers. These polarization properties are also varied by the waviness of the multilayer. A slight difference of condition of the deposition and the frame-mounting of multilayer might cause the difference of the polarization properties. Evaluation of polarization properties is required for every multilayer.

Table 1. Properties of Sc/Cr phase shifters at 398.6eV.

	Maximum Phase Shifting	Incident Angle of Δ=90°	Polarizance at Δ=90°	Transitivity* at Δ=90°
#1	99.1°	59.64°	-0.48	0.21%
#2	125.5°	59.70°	-0.19	0.33%
#3	119.9°	59.46°	-0.38	0.19%
#4	129.4°	59.34°	-0.43	0.20%

Δ: Retardation
*: $(T_S+T_P)/2$