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Analysis of Interfacial Reactions in Ultra-thin $Al_2O_3/SiO_2/Si$ films by SR-XPS

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Introduction

In nano-scale film growth, the analysis of interfacial reactions between substrate and film is important in considering the device abilities. SR-XPS has advantages in analyzing the chemical states changes and elemental bonding at interface due to its energy variability with ultra-brilliant. Al_2O_3 has been consider as one of the candidates for next generation high–*k* dielectrics in C-MOS gate electrodes and metal insulator metal (MIM) electron emitter devices. In the present work, ultra-thin Al_2O_3 films with thickness ranging from 2-10 nm were deposited on SiO_2/Si (100) n-type substrate with thickness 525 µm and interfacial reaction were measured at KEK-PF BL-13C.

Experimental

XPS spectra were obtained using the SR excitation energy with CHA analyzer PHI model 1600C. The analyzer was set at 54.7° to surface normal and analysis area was φ800 µm with solid angle ±7°. The system base pressure during measurement was 2.8 x 10^{-8} Pa. The energy calibration of the system was done using the MoS_2 and Au standard samples.

Results and Discussion

Fig. 1 shows XPS spectra obtained in 3 nm Al_2O_3 film with X-ray excitation energy 730 eV and 1000 eV. The depth of excited photoelectrons showed different characters according to variations in excitation energy. Photoelectron peaks penetrated from Al_2O_3, interfacial layer SiO_2 and substrate Si were observed. In 730eV, Al_2O_3 photoelectron peak appeared strongly. Energy loss appeared as surface Plasmon peak at higher binding energy around 14 eV from main Al_2O_3 photoelectron peak. In 1000 eV where the excitation energy was large, the penetrated photoelectron peaks showed much prominent from SiO_2/Si substrate and surface Plasmon like peaks were not distinct.

Fig. 2 shows the O1s spectra with X-ray excitation energy of 730 eV in the energy separation between main peak and the onset of Plasmon loss which is equivalent to the minimum energy required for an electron to travel across the band gap. Plasmon oscillation is a good approximation to the band-gap energy. In the present experiment the results showed band-gap increase in thicker film. SR-XPS analysis can be useful method for approximation of electronic structure in ultra-thin oxide layer.

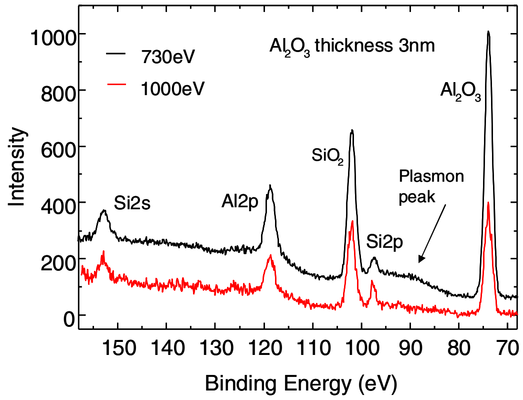

Fig. 1 XPS spectra of $Al_2O_3/SiO_2/Si$ sample

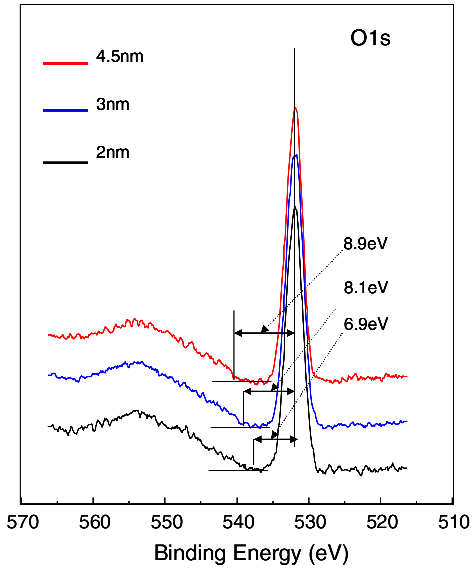

Fig. 2 XPS spectra of O1s photoelectron peaks excited by 730 eV with different film thickness

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