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

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Introduction

Al_2O_3 is one of the prominent materials in various applications such as catalysis, coating, and microelectronics. Especially, in microelectronics it has be consider as one of the candidates for next generation high-*k* dielectrics in CMOS gate electrodes and metal-insulator-metal (MIM) electron emitter devices. In nano-scale film growth, analysis of interfacial reactions between substrate and film are 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. In the present work, ultra-thin Al_2O_3 films with thickness ranging from 2-10 nm were deposited on SiO_2/Si substrate and there interfacial analysis was carried out. .

Experimental

The experiment was carried out at KEK-PF BL-13C. Samples used were Al_2O_3 films with thickness 2, 3, 4.5, 10nm deposited on SiO_2/Si (100) n-type substrate with thickness 525 μm . XPS spectra were obtained using the SR excitation energy from 130-1000eV with CMA analyzer PHI model 1600C. The analyzer was set normal to sample while the excitation beam was set at 55 ° . Analysis area was 800φ μm with solid angle ±7 ° . The system based pressure during measurement was 2.8 x 10^{-8} Pa.

Results and discussion

Fig.1 shows the XPS spectra obtained in 3nm Al_2O_3 film thickness with X-ray excitation energy 730eV and 1000eV. The depth of excited photoelectrons showed different characters according to variations in excitation energy. Photoelectron peaks penetrated from Al_2O_3, substrate Si and interfacial layer SiO_2 were observed. In 730eV, Al_2O_3 photoelectron peak appeared strongly. Energy loss appeared as surface Plasmon peak at higher binding energy around 14eV from main peak. Si2p photoelectron peak together with SiO_2 peak, Al2s and Si2p peaks were also observed. In 1000eV where the excitation energy was large, the penetrated photoelectrons peaks showed much prominent from SiO_2/Si substrate and no Plasmon like peaks were observed.

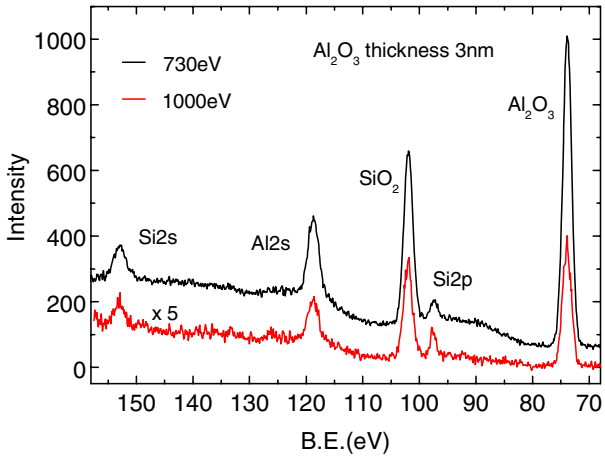

Fig. 1 XPS spectra of $Al_2O_3/SiO_2/Si$ sample with different excitation energies

The other samples with different film thickness were also measured and showed different interfacial characteristic according to the different excitation energy and details of interfacial mechanism will be analyze further.