Evaluation of Al_2O_3 thin films and Al_2O_3/Si interfaces

Al_2O_3 film has the characteristics of chemical stability and good insulating property. Therefore, it is well introduced into a lot of semiconductor devices. However, the quality of Al_2O_3 film easily deteriorates depending on the formation processes. In this study, we investigated the change of chemical states of Al_2O_3 thin films and Al_2O_3/Si interfaces by thermal annealing.

Characteristics and issues of Al_2O_3 films

◆ **Al_2O_3 films**
- Chemical stability
- Wide band gap (6 eV~)
- High dielectric constant (8~)

⇨ Application to a lot pf devices, such as memory devices and power devices

◆ **Issues of Al_2O_3 films**
- Degradation of electrical Properties by carrier trap
- Difficulty to control film quality

⇨ Necessity to control the film quality

⇒ Study on the change of chemical states of Al_2O_3 thin film and Al_2O_3/Si interface by thermal annealing.

Samples and Analyses

◆ **Sample**

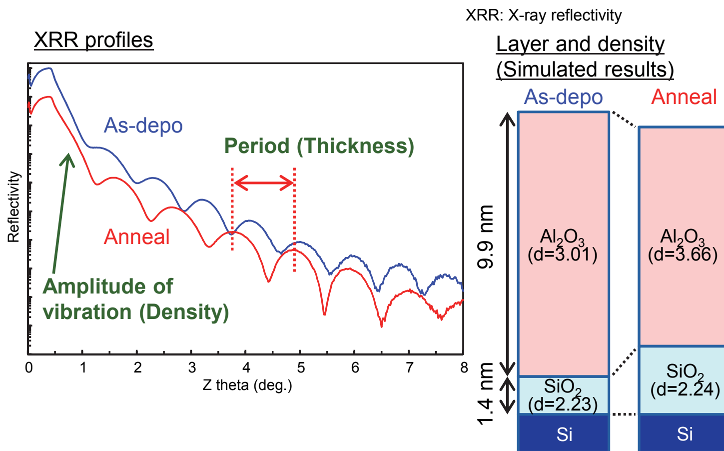
ALD-Al_2O_3 (10 nm)/SiO_2 (1.5 nm)/Si-sub.
- As-depo
- Anneal (900°C)

Al_2O_3
SiO_2
Si

◆ **Analyses**
- Film thickness, density, roughness ⇒ X-ray reflectivity (XRR)
- Chemical bond ⇒ Fourier transform infrared spectroscopy (FT-IR)
- Band gap ⇒ Reflected electron energy loss spectroscopy (REELS)
- Chemical states of Al_2O_3/Si interface ⇒ Hard x-ray photoelectron spectroscopy (HAXPES)

Layer, Thickness and Density: XRR

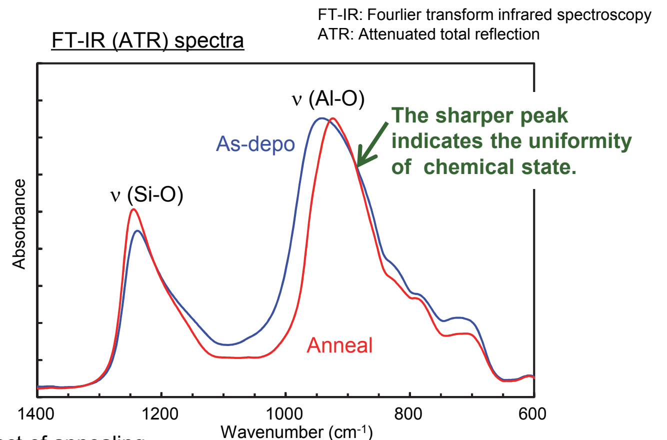
XRR: X-ray reflectivity



Effect of annealing
- Higher density of Al_2O_3 (Thinner thickness)
- Thicker SiO_2 interlayer (No change of density)

Chemical bond of Al_2O_3: FT-IR (ATR)

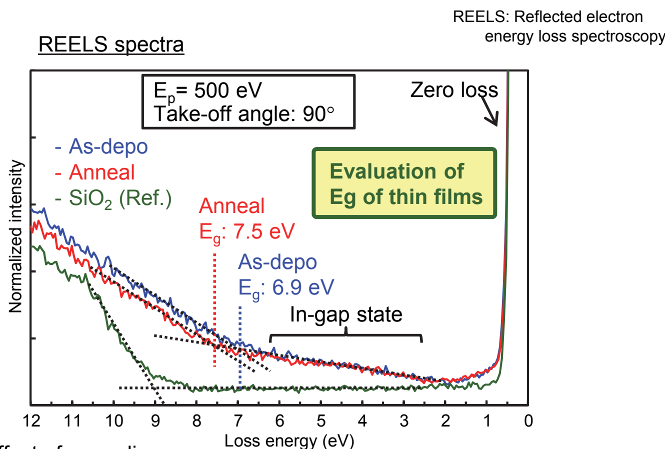
FT-IR: Fourlier transform infrared spectroscopy
ATR: Attenuated total reflection



Effect of annealing
- Decrease in FWHM of Al-O peak ⇒ Uniformity of chemical state (Higher atomic order [crystallinity])
- Increase in Si-O peak intensity and higher wavenumber shift ⇒ Thicker SiO_2 interlayer

Band gap of Al_2O_3: REELS

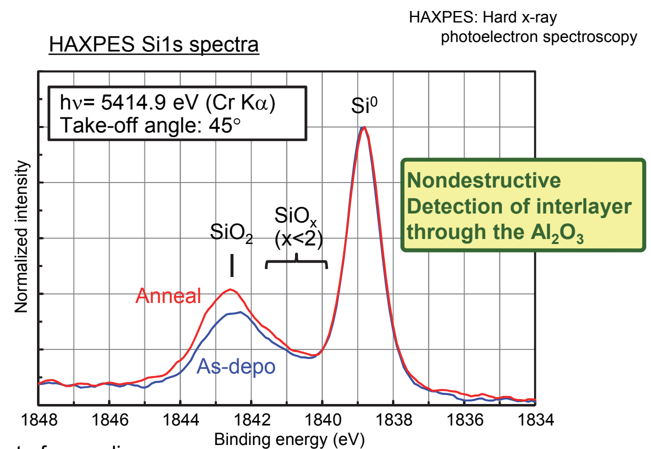
REELS: Reflected electron energy loss spectroscopy



Effect of annealing
- Band gap (E_g): 0.6 eV higher
- No change of intensity of in-gap states (2~6 eV)

SiO_2 Interlayer: HAXPES

HAXPES: Hard x-ray photoelectron spectroscopy



Effect of annealing
- Increase in SiO_2 thickness
- A little increase in sub-oxide states (SiO_x)

Systematic evaluation of stacked dielectric films ⇒ Understanding the film characteristics and stacked layers

P01757表面科学第2研究室20180221

Toray Research Center, Inc. INNOVATION IN EXCELLENCE UP