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VUV Photo-oxidized High Density Silicon Dioxide Growth Condition

Atsuyuki FUKANO[1]*, Hiroyuki OYANAGI[1], Hideki HASHIMOTO[2]
[1]AIST, Tsukuba, Ibaraki 305-8568, Japan
[2]TRC, Sonoyama, Otsu, Shiga 520-8567, Japan

Introduction

With more higher integrated LSI, the gate-dielectric material is studied to SiON and high-k, because of reach for dialectally limitation thickness of SiO_2. However, it becomes recognized that the high quality SiO_2 thin film need interface between substrate and high-k materials. The investigation of high quality SiO_2 thin film is absolutely imperative the generation of high-k dielectric LSI devices. We found that the high density of SiO_2 thin film which is ~2.32g/cm^3 could be layered under VUV irradiation.[1] Also, we found VUV Photo-oxidized film difficult to make sub-oxide layer by XPS analysis. Howbeit, the value of SiO_2 density is depends on growth condition. Therefore, we conduct verification experiments for the condition of high densified SiO_2 film by VUV photo-oxidization.

Experiment

The VUV light source in our previous work was excimer lamp.[1] In contrast to SR with a high degree of monochromaticity, commercial excimer lamp is not fully monochromatic, *i.e.*, bandpass is greater than that of SR beam and purity is poor, *i.e.*, visible and IR radiation are included. Therefore, if we find difference between the two sources, it could be due to the difference in characteristics of light source. From viewpoints of purity of excitation light and controllability of wavelength, the use of SR beam is preferable to investigate the growth mechanism. The growth condition for the SR-beam experiment which is BL-20A is described in the following: wavelength is 126nm and the substrate temperature is chosen from 300, 350 and 450 °C and O_2 gas (1 atm) is flown with a constant rate is 100 ml/min. The SiO_2 film density was measured Grazing Incidence X-ray Reflectometry (GIXR) method.[2]

Result and Discussion

We investigate the relationship between SiO_2 density and growth temperature by 126nm Photo-oxidation. The result of temperature dependence for SiO_2 density is shown Table1. It cannot get a tendency of relationship between growth temperature and SiO_2 density only by the experiment that of SR data. Therefore we took in Excimer lamp irradiation data in Table1. The SiO_2 density value was chosen flat area from the GIXR depth profile. From the string of datatrend shown by a set of data, the maximum density of SiO_2 is inclined 370~380 °C growth temperature and there is as yet no sign of dependence for irradiated VUV source, because of these points variation are smoothly. It though that the densified silicon dioxide film formation is affected VUV irradiation, from this reason. Howbeit, the SiO_2 density which growth temperature is over 400 °C, is reduced in step with increase the temperature. It should be temperature was affected bonding angle of Si-O-Si. The photo-oxidized SiO_2 film thickness which growth temperature of under 300 °C could not measured by GIXR method. It means that, The SiO_2 film could not formed lower growth temperature, even if VUV was irradiated over the sample. The film thickness of SR irradiated sample seems thicker than Excimer lamp. It is thought that photon quantities should be related to it, but a reason will be researched future. In addition, We found that flow quantity of gas was important factor to formation of higher density of SiO_2. It is so difficult to elucidate the mechanism of VUV Photo-Oxidation, but we will try to elucidate of Photo-oxidized mechanism by research for optimized condition.

References

[1] A.Fukano et al., J. Appl.Phys.,94, 3345 (2003).
[2].N.Nagai et. al, Appl.Surf.Sci.,172, 307 (2001).
* a.fukano@aist.go.jp

Table1. The growth temperature dependence of SiO_2 density.

126nm irradiation Source	SR	SR	Excimer Lamp	Excimer Lamp	SR	Excimer Lamp
Growth Temperature (℃)	300	350	385	430	450	480
Density (g/cm^3)	2.26	2.30	2.31	2.27	2.23	2.20