Effect of Added Organic Solution on Low-Temperature Deposition of SiO_x Films by APCVD using Silicone Oil and Ozone Gas

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Introduction: Low-temperature (<300 °C) deposition of silicon oxide (SiO_x) films is widely used not only for multilevel interconnections in VLSI circuits, but also for thin film transistor (TFT) on non-heat resistant glass. Previously, we have reported the low-temperature deposition of SiO_x films using APCVD (atmospheric pressure chemical vapor deposition) with silicone oil (S.O.) and ozone (O_3) gas [1, 2]. S.O. is used as a source material for the formation of SiO_x films at low temperature because it is low cost and safer to use, compared with TEOS (tetraethylorthosilicate) which is conventionally used. However, the deposition rate of SiO_x films using S.O. is low ≤ 3nm/min [1] and the films contain non-negligible amount of Si-OH bonds due to H_2O [2] as much as conventional ones. In order to enhance deposition rate and reduce amount of Si-OH bond, we tried to add some organic solution to S.O. vapor and O_3 gas. In this meeting, these results are presented and discussed.

Experimental Procedure: SiO_x films were deposited on Si substrates by APCVD for 5, 10 and 15 minutes with silicone oil (i.e. decamethylcyclopentasiloxane: $C_{10}H_{30}O_5Si_5$), O_3+O_2, and an organic solution. O_3 was produced with 150g/cm^3 concentration by the electric discharge from 99.999% O_2 gas with the flow rate of 0.5 slm, while S.O. was vaporized at 55 °C by bubbling with N_2 (0.35 slm). The organic gas was introduced into the chamber by bubbling the solution with N_2 gas (0.1 slm) at room temperature. The thickness of the as-deposited films was measured by ellipsometry, and the chemical structure was analyzed by FT-IR (Fourier Transform Infrared) spectroscopy.

Results: Figure 1 shows the FT-IR spectra of the SiO_x films deposited for 15 minutes at 160, 180, 200, and 220 °C. The peaks at 800 and 1070 cm^{-1} are due to bending and stretching of Si-O-Si bonds, respectively, and the peaks at 960 and around 3400 cm^{-1} are due to Si-OH bonds. They are almost similar to the previous reports.

Figure 2 shows the deposition temperature (T_d) dependences of deposition rates of the films deposited with and without the organic solution. It can be seen that, at 200 °C, the deposition rate with or without OS is higher than 6 nm/min, which is larger than the previous one ≈ 3 nm/min. This is probably because the source material of S.O. is different from the previous one of linear polydimethylsiloxane (viscosity 10cSt). However, the deposition rate with OS shows a saturation behavior at high T_d while that without OS increases non-linearly with T_d. At present, we investigate mechanisms of this phenomenon. As for Si-OH bond, although the intensity due to Si-OH bond with OS is a little lower than that without OS, further research on it should be needed for clarity.

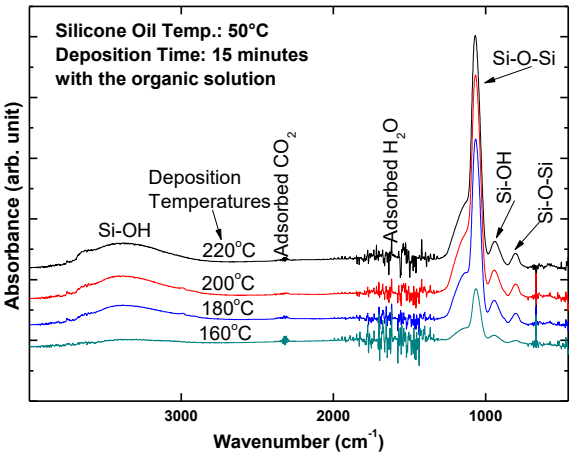

Fig. 1. FT-IR of SiO_x films deposited at 160, 180, 200, and 220 °C for 15 minutes using the organic solution (OS).

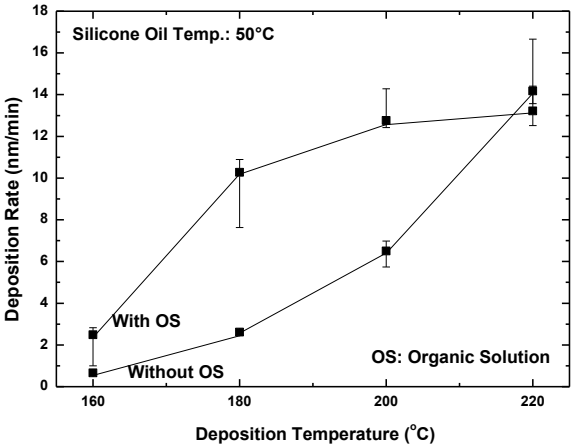

Fig. 2. Deposition temperature dependences of deposition rate of S.O films deposited at 160, 180, 200, and 220 °C with and without the organic solution (OS).

Summary: Adding OS was found to influence the deposition rate strongly and content of Si-OH bond slightly. In the meeting, we will show more detailed data under various deposition conditions and discuss them.

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Reference: [1] Y. Taniguchi *et* al., Abstract JSAP 59th Spring Meeting, 2012, 15p-Gp-1-2. [2] Horita *et* al., *Jpn, J. Appl. Phys.*, **48**, (2009) 035502.