Reduction of Hydroxyl in the Low-Temperature Si Oxide Films Fabricated under Various Deposition Conditions

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1. Introduction: For low-temperature deposition of Si oxide films, we have been investigating APCVD (Atmospheric Pressure Chemical Vapor Deposition) method with silicone oil and ozone gas. Compared with the conventional CVD methods, this method has some advantages of low cost and use of safe materials. However, there is a serious problem of remained OH bonds in the films, which degrade insulator property of the Si oxide films. Recently, we found that increasing ozone concentration can lower the OH content. In this meeting, the results are presented and discussed.

2. Experimental procedure: Si oxide films were deposited with the aid of trichloroethylene (TCE) under 200℃ substrate temperature. The details were mentioned in the previous report.[1] The ozone concentration was changed from 43 to 97 g/m^3 in the reaction chamber. For estimation of OH content in a film, FT-IR (Fourier Transform Infrared Spectroscopy) measurement was conducted, and the spectra were deconvoluted to distinguish OH-related component from other ones. For the measurement of deposition rate, we use the same deposition time (10 min) for all samples and measure the film thickness and refractive index by ellipsometry method.

3. Results and discussion: Figure 1 shows the FT-IR spectra of the Si oxide films, which were fabricated with four different ozone concentrations. The peaks in the high wavenumber range around 3400 cm^{-1} and the low wavenumber around 950 cm^{-1} are related to H_2O/-OH and -OH, respectively.

Figure 2 shows the variation of (a) the peak area ratios and (b) the deposition rate R_d and refractive index n with the ozone concentration C_{O3}, where the ratios are between the high (3400 cm^{-1}) wavenumber and the main SiO_2 TO3 peaks, and the low (950 cm^{-1}) and the TO3 ones. From these results, we can see that increasing the C_{O3} reduces the OH contents and enhances the deposition rate. The enhancement of R_d is high until C_{O3} is up to ~60 g/m^3, but, after that, R_d becomes saturated. This means that R_d is limited by supply amount of O_3 up to C_{O3} = ~ 60 g/m^3 and that C_{O3} more than 60 g/m^3 is sufficient for the reaction. However, H_2O and OH contents are further reduced with more C_{O3}, which suggests that excessive C_{O3} has a reduction effect on H_2O and OH contents. Also, this effect leads to increase of n or mass density of the deposited films.

4. Summary: Although we show high ozone concentration has OH removal effect, the detailed mechanism is still unknow. So, in the meeting, we will discuss it and show the other data.

Reference: [1] Horita et al., 2018 Jpn. J. Appl. Phys. 57 03DA02。

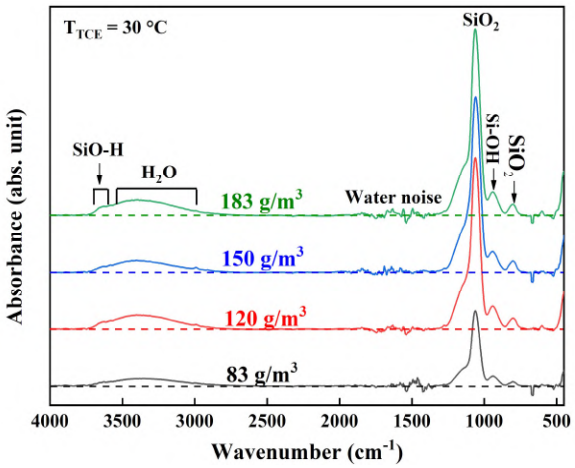

Figure 1. FT-IR spectra of the Si oxide films deposited with various ozone concentrations.

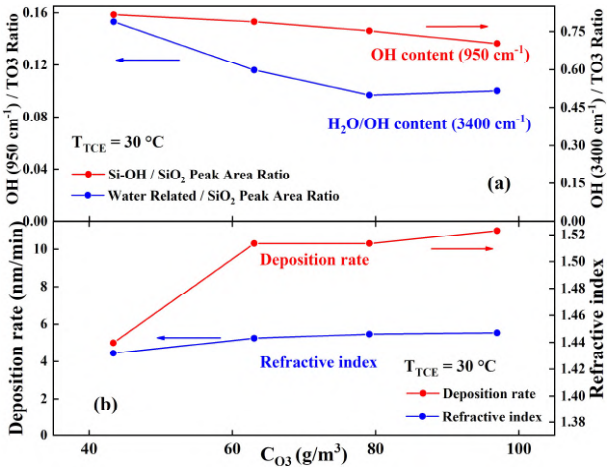

Figure 2. Ozone concentration dependences of (a) OH and water contents, and (b) deposition rate and refractive index.