Atmospheric Pressure Deposition of Silica Thin Films by Photo-CVD using Vacuum Ultraviolet Excimer Lamp

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It has been known that silica films can be deposited from TEOS [$Si(OC_2H_5)_4$] by a photo-chemical vapor deposition (CVD) technique using vacuum ultraviolet (VUV) light at room temperature. In this work, in order to develop an advanced technique of this, we have tried the silica film deposition at the atmospheric pressure.

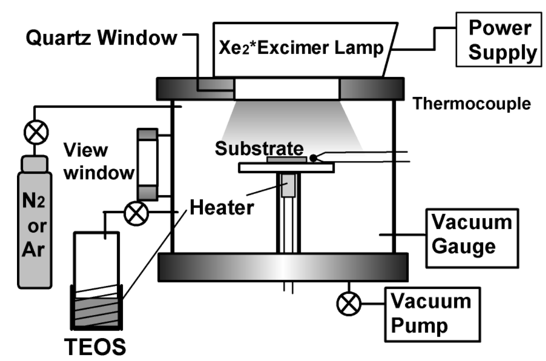

Figure 1 A schematic drawing of the experimental setup.

Figure 1 shows a schematic drawing of the experimental setup. The Xe_2* excimer lamp (λ=172 nm) was used as a light source and located on the top of the chamber. The light from the lamp was introduced into the chamber though a quartz window. A silicon (100) wafer was used as a substrate. TEOS was used as a precursor. TEOS is introduced into the chamber by reducing once the pressure in the chamber down to about 3 x 10^{-4} Torr. Then, the total pressure in the chamber was adjusted to the atmospheric pressure by N_2. We have set that the substrate temperature was R.T.-100^{o}C and the distance between the window and the substrate was 15-20 mm.

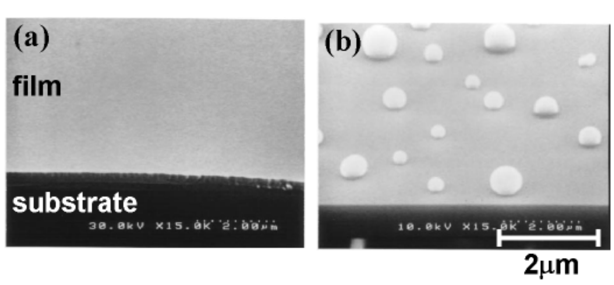

Figure 2 SEM photographs of typical films obtained (a) at 1 and (b) 760 Torr.

Figure 2 shows SEM photographs of typical films obtained at 1 and 760 Torr. In the photographs of the film obtained at 1 Torr, a thick and flat film was observed on the substrate. However, rising the total pressure, the surface became rougher. In the case of the deposition at more than 100 Torr, the substrates were covered with flat films and many particles of about 1μm in diameter were observed on the film.

Figure 3 shows SEM photographs of films obtained at the substrate temperature of R.T. and 100^{o}C and the distance of 15 and 20 mm. In the case of 15 mm, the flatness of the film was increased with the substrate temperature. The thermal energy at 100^{o}C is considered to be sufficient for the activation of the surface reaction to fuse the particles and the film. In the case of the distance at 20 mm, only the flat films have been observed for all the temperatures.

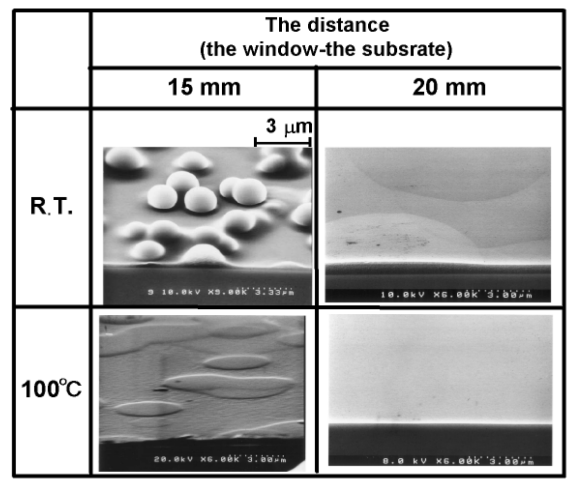

Figure 3 SEM photographs of films obtained at the substrate temperature of R.T. and 100^{o}C and the distance of 15 and 20mm.

The observation in the chamber from the view port, the white fume was generated and started to move along the radial direction near the window soon after switching the lamp on. We considered, when the distance is 15 mm, the particles were trapped on the surface of the film. On the other hand, when the distance is 20 mm, the convection along the radial direction between the window and the substrate is considered to be almost complete laminar flow, so, the particles move along the flow lines effectively without the trapping.

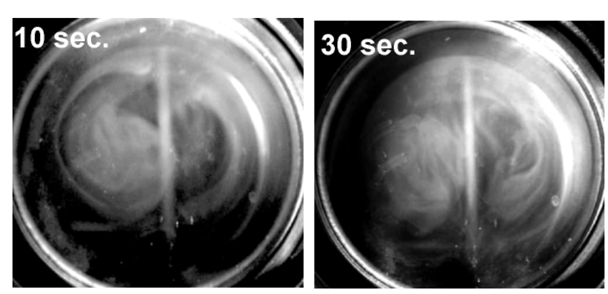

Figure 4 The photograph of the observation in the chamber.

In conclusion, we have experimentally demonstrated the fabrication of the silica film by VUV-CVD at the atmospheric pressure. Silica films have been deposited successfully at the atmospheric pressure by VUV-CVD. The relatively flat film could be obtained by rising the substrate temperature to 100^{o}C. Furthermore, very flat films could be obtained by setting the distance between the window and the substrate at 20 mm even in the case of room temperature deposition. It was found that the fabrication of the silica film by VUV-CVD at the atmospheric pressure is possible.