Improvement of Deposition Rate of Silica Film in the Vacuum Ultraviolet CVD using a Excimer Lamp by Applying the Bias

Yoshikazu MOTOYAMA[#*],
Hideaki YANAGITA[#], Yoshinari MAEZONO[#],
Atsushi YOKOTANI[#] and Kou KUROSAWA[#],

[*]LSI Process Engineering Department Miyazaki OKI Electric Co., Ltd.
Miyazaki 889-1695, Japan

[#]Faculty of Engineering, Miyazaki University, 1-1, Gakuenkibanadai Nishi, 889-2192, Miyazaki, Japan
TEL: +81-985-58-7357; FAX: +81-985-58-7345

Deposition of silica films is very important for the fabrication of ultra-large scale integrations (ULSIs), because they are available for gate oxide, inter-layers insulators, scarifies and so on. Recently, we have proposed a new technique for deposition of silica film from a single precursor (tetra-ethoxy-ortho-silicate: TEOS) by vacuum ultra-violet (VUV) CVD. In the technique, it have been known that the deposition rate becomes 2 - 5 times faster and reaches at the level of practical application when the O_2 is mixed to the TEOS. However, since such a film contains much amount of hydroxyl, electric resistivities become too low to use for the insulators in ULSIs. So in this work, we purpose a new technique to improve the deposition rate without adding O_2 by applying electric bias to the substrate.

Figure 1 shows a schematic drawing of the VUV-CVD system used in this work. Three Xe_2* excimer lamps were located at the top of the main chamber. The wavelength is 172 nm. The light intensity used in this work was 10 mW/cm^2 at just beneath the window. TEOS vapor was introduced in the main chamber through a vaporizer. A Teflon sheet of 2 mm thick was sandwiched by the stage and a sample wafer of 5 inches in diameter. A static bias voltage of positive or negative 300 V was applied against the stage which was electrically connected to the chamber and maintained at 0 V. The obtained films were characterized by an FT-IR, an ellipsometer, and a leakage current measuring equipment.

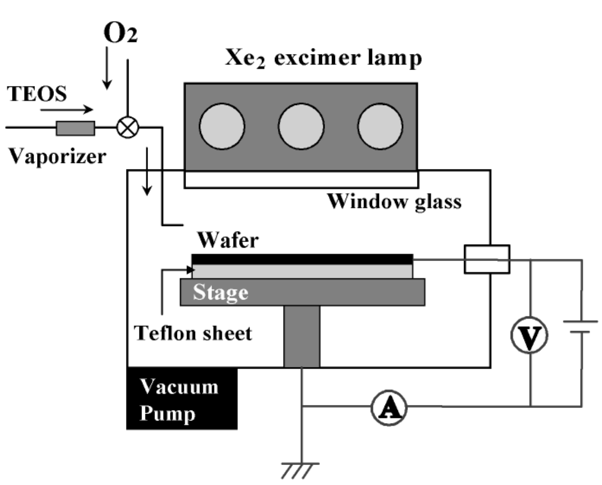

Fig.1 Image of VUV-CVD system.

Figure 2 shows the deposition rate of the film prepared with and without the bias. The deposition rate was successfully improved by 6 times at relatively lower pressure when the negative bias was applied. However a significant difference was not observed at the higher pressure. This limitation of the rate is closely related to the intensity of the VUV light. We consider that the higher deposition rate at the higher pressure should be achieved if more intense light source is used.

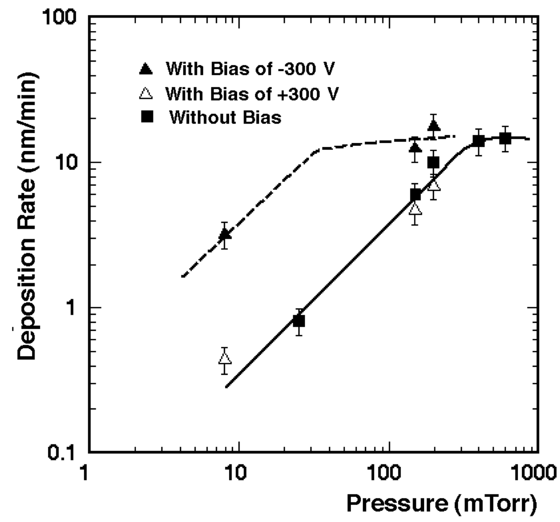

Fig. 2 Deposition rate to TEOS pressure in case of change bias.

Figure 3 shows the results of the measurement of the leakage current density. As shown in Fig.3, the leakage current density of the negatively biased samples was found to increase slightly. However, the value was almost the same as the case with the pressure of 300 mTorr without the bias. Moreover, these leakage currents are at least one order of magnitude smaller than that of O_2-added films.

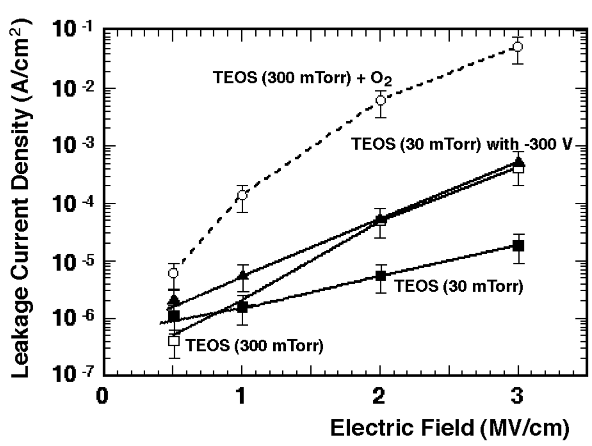

Fig. 3 Leakage current density to electric field of SiO_2 films with various conditions.

We have performed silica film deposition from TEOS by the VUV-CVD applying the bias voltage to the substrate in order to improve the deposition rate without using an additive gas such as O_2. As a result, the deposition rate has been successfully improved by 6 times by applying the negative voltage of 300 V. Although this effect for the rate is comparable to the O_2-adding, the deterioration in electric properties of the film is much less. Although the mechanism has not been apparent at this moment, this technique should be very important and useful in the practical semiconductor fabrication.