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XeCℓ EXCIMER LASER OXIDATION OF Si EMPLOYING $O_2/C\ell_2$ GAS MIXTURE

Keiji HORIOKA, Haruo OKANO and Yasuhiro HORIIKE

Toshiba VLSI Research Center, Toshiba Corp.
Komukai Toshiba-cho 1, Saiwai-ku, Kawasaki 210, Japan

Recently, applications of photo-excited reaction to the IC manufacturing are noted intensively because of the low temperature and radiation damage-free process. In the course of studying UV light-excited Si etching employing $C\ell_2$[1,2], a new phenomenon of XeCℓ excimer laser oxidation of Si was found, when O_2 was added to $C\ell_2$. This report discusses the growth mechanism and also the film characteristics.

Figure 1 shows an experimental apparatus. A XeCℓ excimer laser beam (308 nm) with a 10 x 20 mm^2 area is irradiated through a quartz window to a Si surface which is set in a reaction champer filled with a O_2 + $C\ell_2$ mixture. The laser repetition frequency and the average power are 80 pps and $2W/cm^2$, respectively. The sample is an p type (boron doped, 9-11 Ωcm)(100) single Si. The sample is dipped in the BHF to remove natural oxide just before setting it the sample stage. Indeed, when the surface is covered by the natural oxide or thermally grown oxide, the photo-excited oxidation does not take place at all.

Figure 2 shows the AES in-depth profile of the present film obtained by the laser irradiation in a $C\ell_2$ (10 Torr) + O_2(200 Torr) mixture at 250°C, 10 min. This demonstrates a proper structure of stoichiometric silicon oxide. No Cℓ signal was detected with present AES sensitivity.

Figure 3 shows variations of the Si etched depth and oxidized layer thickness as a function of O_2 partial pressure, where $C\ell_2$ partial pressure is fixed at 10 Torr. The oxidation morphologies are also inset. In the absence of O_2, only Si etching occurs with photo-dissociated Cℓ radical. With increasing O_2 pressure, the etched depth decreases, while the oxidized thickness increases inversely and then attains a maximum at 100 Torr. This opposite characteristic suggests that the oxidation is performed by the reaction between the etching product and the O_2 gas. Hence, decrease in oxidation rate above 100 Torr O_2 partial pressure results from insufficient Si chloride. The silicon chloride may consist of unsaturated $SiC\ell_x$ (x=1~3) gas, because the deposition rate of SiO_2 produced employing a $SiC\ell_4$, O_2 and $C\ell_2$ mixture shows only 1/80, as compared with the maximum oxidation rate in Fig. 3 under the same condition of O_2 and $C\ell_2$ partial pressures. Accordingly, the unsaturated $SiC\ell_x$ is considered to be more active than the stable $SiC\ell_4$.

The step profile between Si and SiO_2 surfaces can be tailored by varying the O_2 partial pressure, as shown in Fig. 3. Figure 4 shows a SEM micrograph of selectively oxidized Si feature obtained at 100 Torr. The oxide is buried in the Si substrate which is not masked by thermally grown SiO_2. This planarized structure may be used for a new field isolation. However, some problems are still remained for the film properties. The high etch rate of 0.4 μm/min in BHF after 800°C O_2 annealing shows a porous structure of this film. Really, an oxidized thickness vs. time characteristic points out a linear law till 2000 Å oxide thickness. The improvement on the film properties requires more intensive study.

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References

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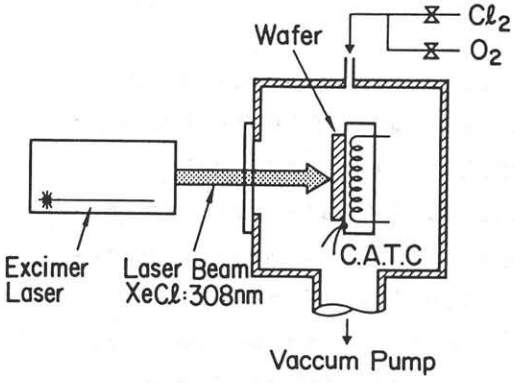

Fig.1 Experimental apparatus

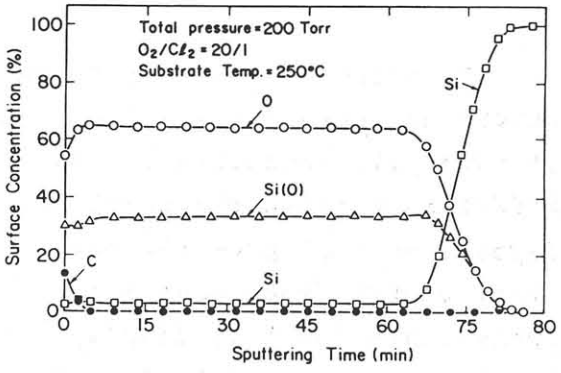

Fig.2 AES in-depth profile of photo oxidized SiO_2.

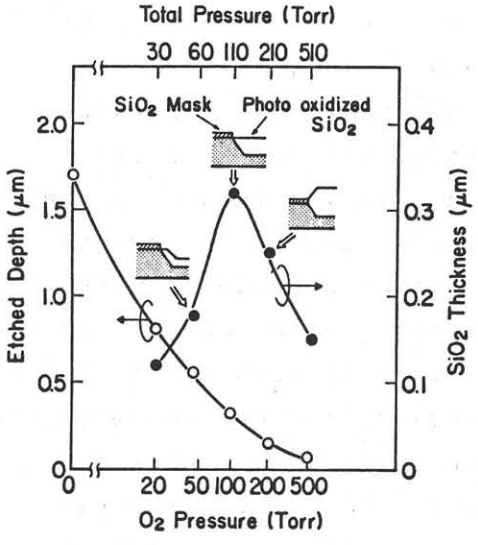

FIg.3 Si etched depth and oxidized thickness vs. O_2 partial pressure. Cl_2 pressure is 10Torr. Substrate temperature and oxidation time are 250°C and 10min, respectively.

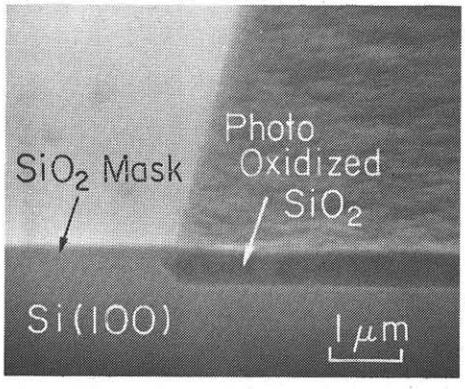

Fig.4 Selectively oxidized Si surface with thermally grown SiO_2 mask.