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Novel Dry Cleaning Using Si_3H_8 with the New Single-Wafer Reactor

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In recent ULSI technology, low temperature process has been playing important role obtaining high speed performance of the devices. Several methods were proposed to obtain low temperature epitaxial growth, but still use hydrogen prebaking in temperature of 900 ℃ [1].

We have suceeded in the development of a novel dry cleaning technique by using Si_3H_8 as pretreatment gas under low-pressure (4 Torr) and low-temperature (820 ℃) with the new single wafer reactor without special treatments such as UV-light irradiation or plasma enhancement.

Figure 1 shows the new single-wafer reactor we developed, has the advantages of flexibility and controllability. The ejection head is formed from an inverted conical housing whose open end is covered by a circular perforated plate. Wafer is placed on a resistance heating susceptor of SiC coated graphite. Figure 2 shows the growth sequence. Wafer was treated with 2% HF solution. Si_3H_8 treatment of 1 minute was done under the condition of Si_3H_8 0.8 SCCM, H_2 4 SLM, 4 Torr, and 780 ~820 ℃. Then, epitaxial layer was grown under the condition of Si_3H_8 1.6 SCCM, H_2 4 SLM, 4 Torr, and 780℃.

Figure 3 shows surface morphology of the obtained epi-layers observed by Nomarski microscope. Without Si_3H_8 treatment (a), very rough surface was observed. With Si_3H_8 treatment (b,c,d), smooth surface were observed and defect was decreased with increasing in the treatment temperature. Treatment temperature of 820 ℃ is resulting in low defect density level.

Figure 4 shows the results of SIMS analysis of these films. Figure 3 (a) ~ (d) are corresponding to Fig. 4 (a) ~(d). From Fig. 4, oxygen and carbon existed at the interface between deposited Si layer and substrate in case of no Si_3H_8 treatment. Increasing in Si_3H_8 treatment temperature, oxygen and carbon were reduced and were almost negligible at 820℃.

From these results, it is apparant for the first time that Si_3H_8 treatment of 820℃ have oxygen and carbon removing ability. Cause of this ability is considered as reduction reaction between native oxide including carbon contamination and Si_3H_8. Si_3H_8 treatment can reduced pretreatment temperature from 900℃ to 820 ℃ with our new single-wafer reactor.

Our new single-wafer reactor and low-temperature process is advantageous for production of future high performance ULSIs.

[1] F. Mieno, etal., Proc. of the second int. symposium on ULSI science and technology 1989, P279.

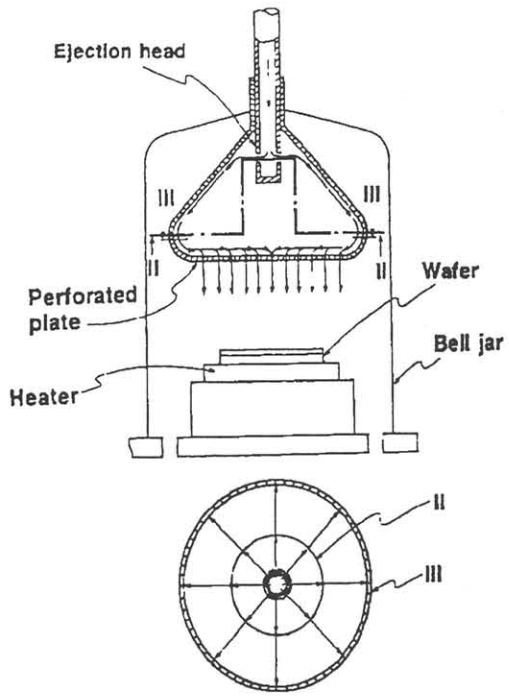
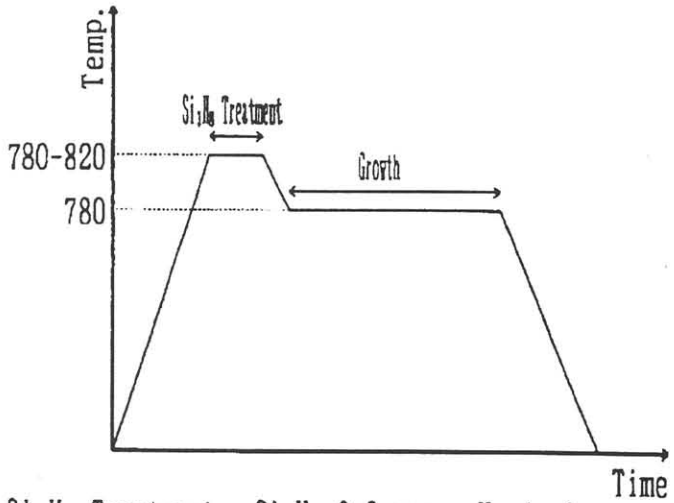


Fig. 1 The new single-wafer reactor



Si_3H_8 Treatment : Si_3H_8 0.8 sccm, H_2 4 slm, 780-820℃, 4 torr, 1 min

Growth : Si_3H_8 1.6 sccm, H_2 4 slm, 780℃, 4 torr, 20 min

Fig. 2 The growth sequence

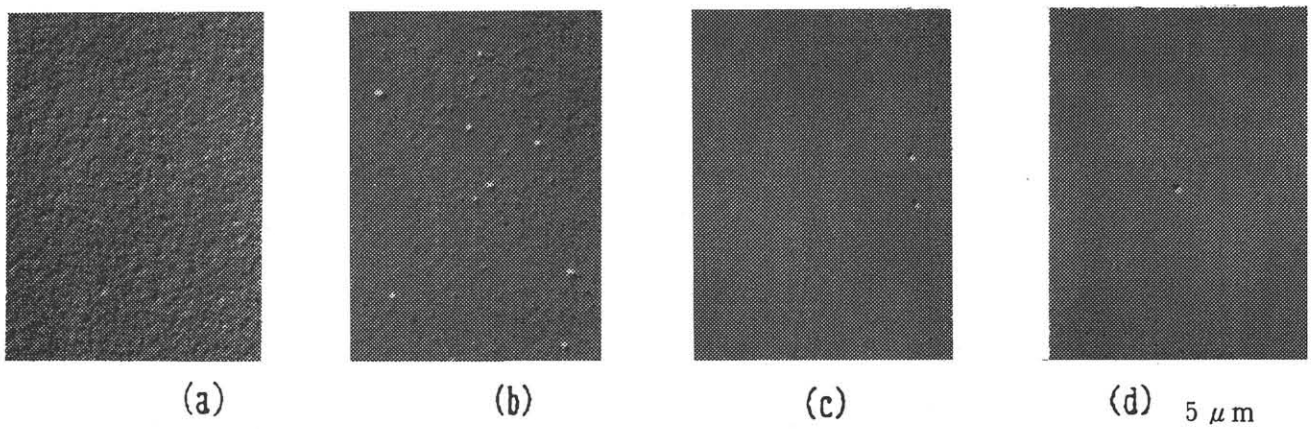


Fig. 3 Nomarski microphotographs

(a)without Si_3H_8 treatment, (b)Si_3H_8 treatment at 780 ℃, (c)Si_3H_8 treatment at 800 ℃, and (d)Si_3H_8 treatment at 820 ℃.

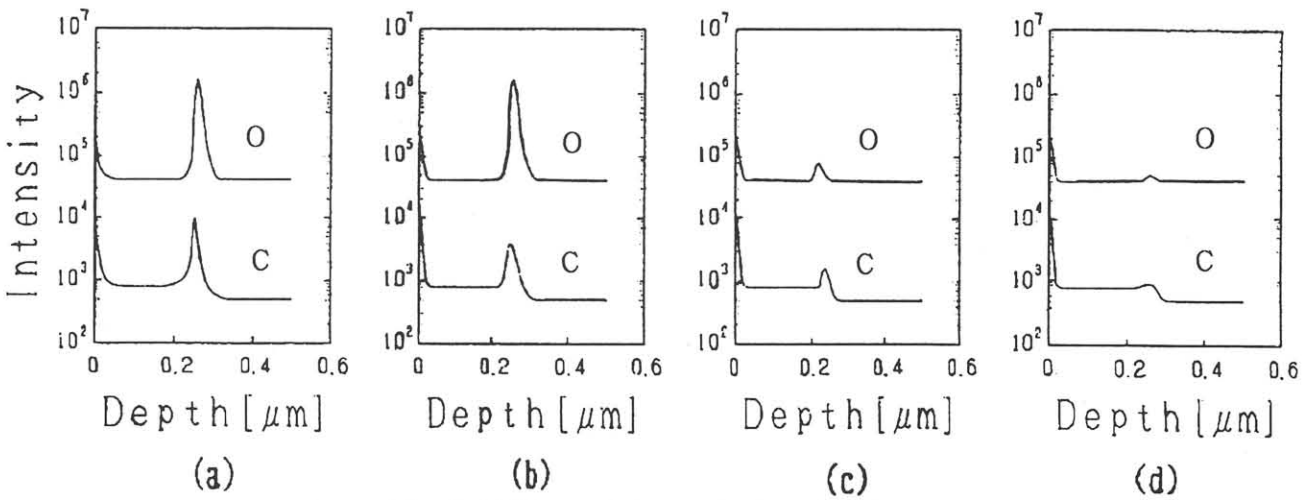


Fig. 4 SIMS profiles of the obtained films