Three Dimensional Improvement of Field Oxidation by Using High Pressure Oxidation for the Gigabit Density Field Isolation

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This paper presents the results of High Pressure Oxidation (HiPOx) applied to Poly Buffer LOCOS isolation for 1μm pitch design rules. We demonstrate that oxidation temperature higher than 1000°C together with HiPOx must be used to improve appreciably field oxide thinning in subhalfmicron spaces as low as 0.35μm. For the first time, we report that field oxidation must be performed at temperatures higher than 1000°C to avoid negative impacts of HiPOx on diffusion corner encroachment.

1. INTRODUCTION
It is relevant that classical LOCOS isolation suffers from field oxide thinning [1],[2] and corner encroachment enlargement [3],[4]. HiPOx offers the possibility of reducing field oxide thinning. Only small improvement has been demonstrated on 0.7μm spaces for Poly Buffer LOCOS[5]. To ensure design rules packing improvement, one must check also that two dimensionnal bird’s beak growth is acceptable.

2. EXPERIMENTAL DETAILS Poly Buffer LOCOS (PBL) results are given. Temperatures as high as 1100°C and oxidation pressure as high as 20 atmospheres have been used. Time was set to grow 600 nm field oxide under steam ambient. Generally, the high pressure oxidation induces oxidation during the transient pressurization step: at temperatures above 900°C, a significant thickness of oxide may be grown with steam during the pressure ramping up to the target pressure. In order to minimize this transient oxidation, it is essential to pressurize the tube with non-oxidizing or minimum-oxidizing ambient. Therefore, the pressurization was achieved with oxygen ambient for temperatures below 1000°C and N2/O2 for temperatures 1000°C or higher. Steam was injected 0.67 atmosphere below the target pressure in order to replace the ambient by steam for the oxidation. Pressurization Rate was 1.67 atmosphere per minute. Temperature ramp-up rate was 8°C per minute.

3. BIRD’S BEAK Figure 1 shows the SEM cross section of 1 μm pitch active area arrays after oxide growth. Field oxidation was performed at 1100°C under 20 atmospheres. Bird’s beak growth is due to

![Figure 1 SEM cross section of 0.43μm space. Oxidation at 1100°C under 20 atmospheres steam for Poly Buffer LOCOS isolation in a 1μm pitch array.](image-url)
nitride edge oxidation and the contribution of the sealed part of encroachment in the oxidized poly. Figure 2 shows the evolution of bird's beak as a function of pressure at different temperatures. We emphasize the decrease of bird's beak with increasing steam pressure because of the decrease of the linear part of oxidation kinetics. The lateral diffusion enhancement of oxygen in polysilicon with increasing temperature will increase the bird's beak like in a SILO (Sealed Interface Local Oxidation) [6] isolation structure.

4. FIELD OXIDE THINNING Relative field oxide thinning is represented on figure 3 as a function of small gaps between active areas. Field oxide thinning is improved by temperature and pressure increase: the effect of pressure is significant for temperatures higher than 1000°C due to nitride edge oxidation rate enhancement (figure 4).

5. CORNER ENCROACHMENT
The other important parameter to control in PBL isolation is the diffusion corner encroachment. In sub-halfmicron geometries, we observe an increase of bird's beak with increasing temperature (figure 5) whilst the ratio between the corner and the straight line bird's beak decreases with increasing temperature. More generally, the given ratio is improved but high pressure can degrade it at temperatures lower than 1000°C (figure 6) because the encroachment growth is due to oxygen diffusion in pad oxide.

6. ACTIVE AREA DEFECTS
Microtrenching defects are revealed in a Poly Buffer LOCOS isolation scheme due to induced stress during the poly removal.
Figure 5 SEM top view of Poly Buffer LOCOS corner encroachment under high pressure oxidation conditions (20 atmospheres) for finished active patterns of (a) 0.17 μm oxidation at 1100°C (b) 0.22 μm oxidation at 975°C.

Figure 6 Relative corner encroachment dependance on finished active width under high pressure conditions at 975°C, 1000°C and 1100°C.

Figure 7 Existing defects as a function of finished active width under high pressure oxidation at 975°C, 1000°C and 1100°C.

References