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# 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 temperatures1000°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

Figure1 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

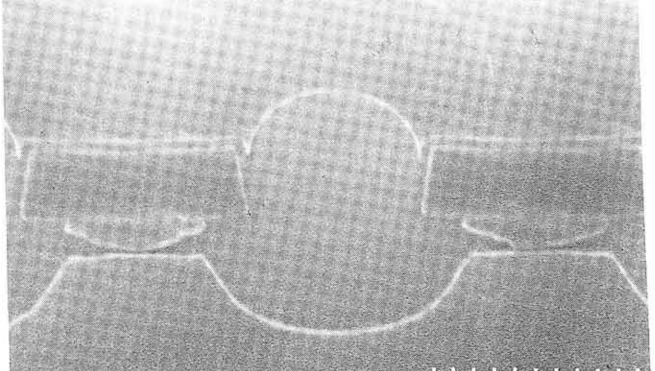



Figure 1 SEM cross section of 0.43µm space. Oxidation at 1100°C under 20 atmospheres steam for Poly Buffer LOCOS isolation in a 1µm pitch array.

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

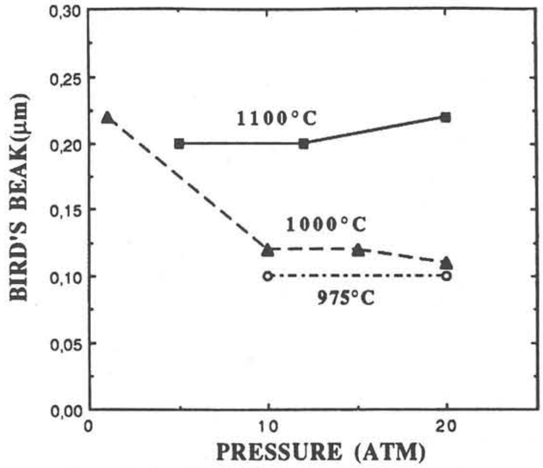



Figure 2 Bird's beak dependance on steam oxidation pressure for different temperatures. Poly Buffer LOCOS isolation.

steam pressure because of the decrease of the linear part of oxidation kinetics. The lateral diffusion enhancement of oxygen in polysilicon with increasing temperaturewill 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 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 subhalfmicron 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,

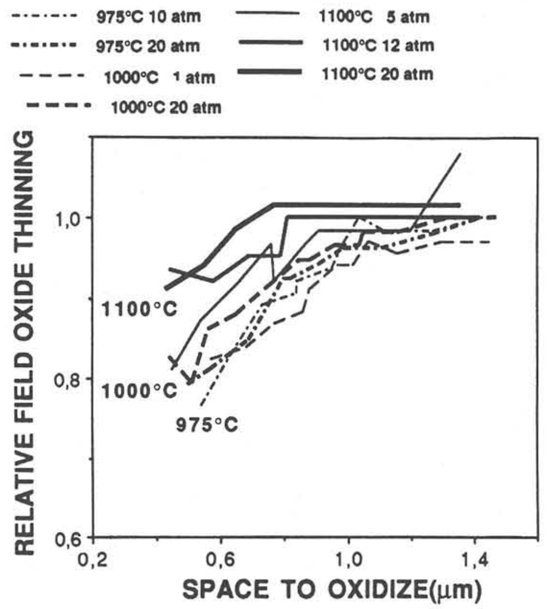



Figure 3 Relative field oxide thinning dependance on space to oxidize at 975°C, 1000°C and 1100°C.

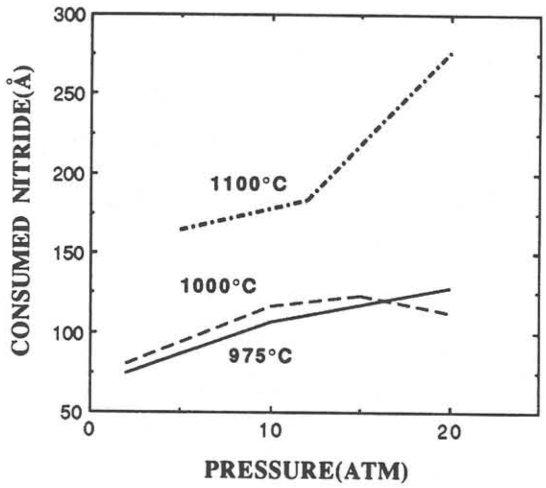


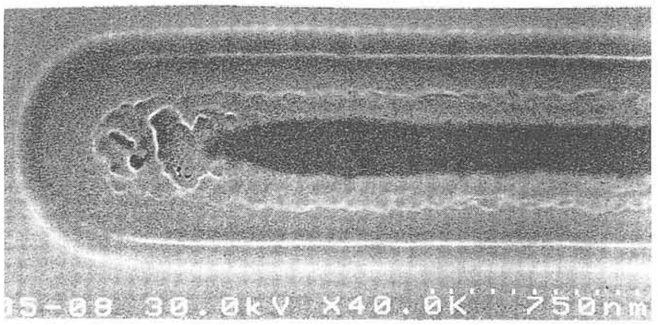

Figure 4 Consumed silicon nitride thickness during a 600 nm steam oxidation as a function of pressure at 3 different temperatures.

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

(a)



(b)

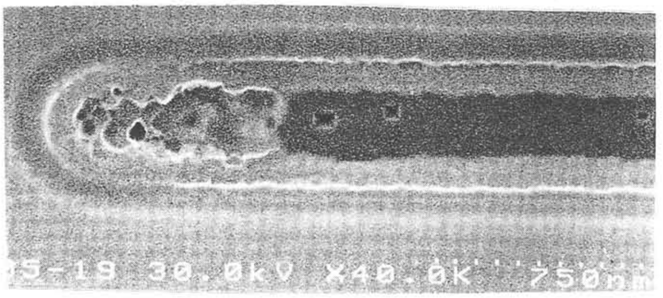


Figure 5 SEM top view of Poly Buffer LOCOS corner encroachment under high pressure oxidation conditions ( 20 atmospheres) for finished active patterns of (a) 0.17µm oxidation at 1100°C (b) 0.22µm oxidation at 975°C.

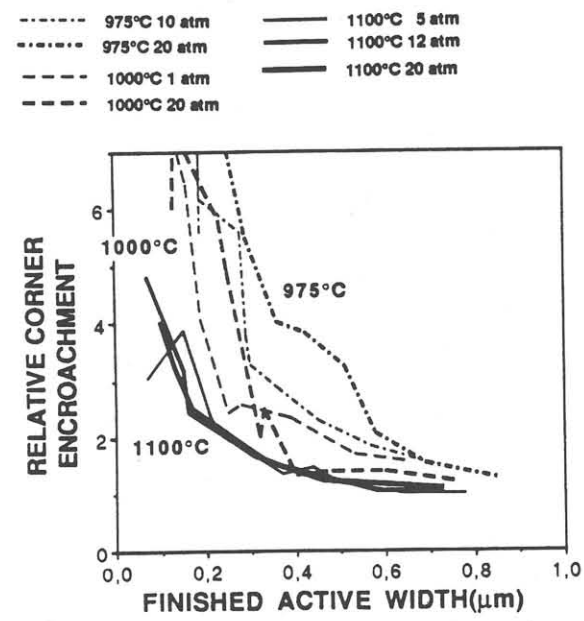



Figure 6 Relative corner encroachment dependance on finished active width under high pressure conditions at 975°C, 1000°C and 1100°C.

step [7] (see also figure 5). The existence of these defects is released by field oxidation temperature increase. Figure 7 shows the dependance of microtrench defects as a function of active area width at oxidation temperatures of 975, 1000, 1100°C: the limit for which microtrenches appear in the active area is pushed down to lower geometries with increasing temperature because of stress relaxation into the pad oxide. Pressure has no effect on this property because oxidation time should be already lower than defects relaxation time at high temperature under 1 atmosphere.

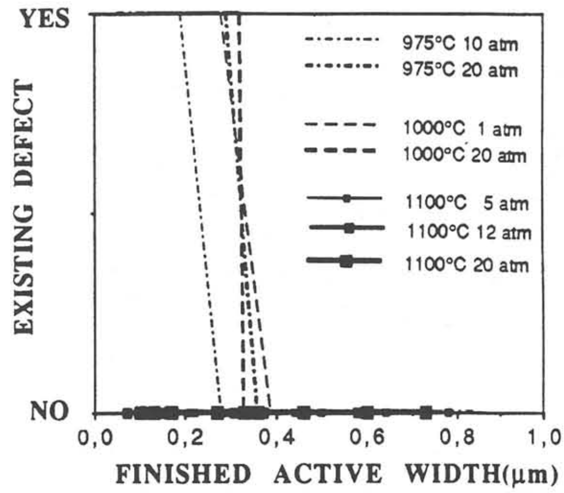



Figure 7 Existing defects as a function of finished active width under high pressure oxidation at 975°C, 1000°C and 1100°C.

## References

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