C — 6 — 3 Dislocation Generation due to Stress Induced by Oxidation in Si Grooves

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Local oxidation of Si crystal is used in the isolation process such as iso-planar or LOCOS. CVD Si_3N_4 films are partly covered on the Si crystal to prevent oxidation. Deposited CVD Si_3N_4 films on Si surface induce stress in Si crystal and sometimes dislocations are generated from the film edge during oxidation[1]. We found dislocation generation when Si crystal was annealed in an oxygen ambience, on the surface of which was not covered by any CVD film.

Figure 1 shows the sample preparation process. Narrow grooves of 5μm (or 3μm) depth were made by dry and wet etching. It was confirmed by X-ray topography that no defect or no damage was induced in Si crystals before oxidation.

Figure 2 shows an optical (Fig.a) and an X-ray photograph (Fig.b) of the specimen which was annealed at 1000°C for 960 min. in a wet O_2. Many dislocations are observed to be formed at pattern edges. It should be noted that these dislocations are generated from fine grooves and glide in {111} slip planes.

Figure 3 shows optical photographs of a surface (Fig.a) and a cross-section (Fig.b) of the specimen annealed at 1000°C for 960 min. in a wet O_2. Parallel five grooves were arranged with a space little smaller than the width of a groove before oxidation. After oxidation, the Si space located between grooves are oxidized as shown in Fig.3(b). Many dislocation etch pits are observed in Si crystal under the grooves as shown in the middle of Fig.3(b).

From these results, it is clearly shown that dislocations are generated by the stress induced in the grooves during oxidation. Volume of silicon expands about 2.3 times when it changes to silicon dioxide. Silicon dioxide grown in the bottom of a groove cannot horizontally expand and therefore stress will be induced in it. The stress can be easily released if silicon dioxide is soft enough to distort, or the stress is stored in it. Dislocations will be generated, when the stress is larger than the critical shear stress of Si crystal[2].

Figure 4 shows calculated stress curves induced in silicon dioxide grown in a bottom of Si groove with 4μm width. Relaxation of induced stress by silicon dioxide distortion is counted in the calculation. The higher the oxidation temperature, the smaller the stress becomes, because viscosity of silicon dioxide becomes smaller. It is sure that the stress goes over the critical shear stress (5×10^8 dyn/cm^2)[2], when silicon grooves of 4μm width is oxidized at 1000 C for 960 min..

REFERENCES

1) S. Isomae, Y. Tamaki, A. Yajima, M. Nanba and M. Maki, J. Electrochem. Soc. 126, 1014 (1979)

2) T. Suzuki and H. Kojima, Acta Met. 14, 913 (1966)

No.	Process		Cross section
1	Si water	FZ(111)(CZ(100))	
2	Oxidation(wet)	1000°C, 120min (0.53μm)	SiO_2
3	CVD Si_3N_4 deposition	0.05μm	Si_3N_4
4	Lithographing		
5	Dry etching	5μm(or 3μm)	
6	Wet etching	0.2μm	
7	Si_3N_4 & SiO_2 etching		
8	Oxidation(wet)	15 -3840 min (0.2 ~4.5μm)	SiO_2
9	Characterization	X-ray topograph Etching	Dislocation

Figure 1. Sample preparation process. The damage induced by dry etching was removed by wet etching.

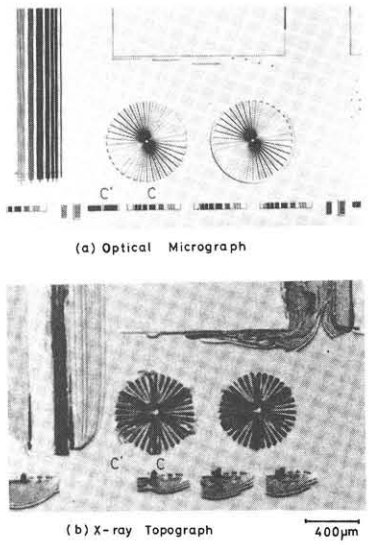

Figure 2. Optical micrograph (a) and X-ray topograph (b) of the specimen annealed at 1000 °C for 960 min. in a wet O_2.

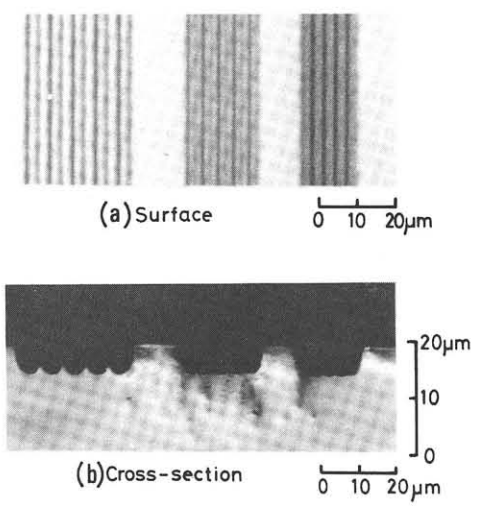

Figure 3. Optical photographs of a surface (a) and a cross-section (b) of the specimen annealed at 1000 °C for 960 min. in a wet O_2.

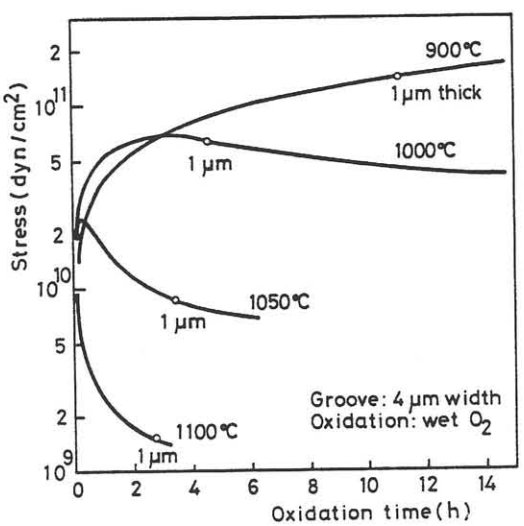

Figure 4. Calculated stress curves induced in silicon dioxide grown in a Si groove.