Growth of 300 mm Silicon Single Crystals in a 24” Hot Zone

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Growth technique of 300 mm silicon crystals is different from that of 200 mm silicon crystals (1). Most of the 300 mm crystals are now produced in 32” hot zones. In this work, new configuration of heat shield and modified process were developed to produce commercial grade 300 mm silicon crystals using a 24” hot zone with 140 kg charge. This new technology has advantages such as low investment and easy to manage over those using a 32” hot zone.

Experimental

300 mm silicon crystals were grown in a KX-150MCZ crystal puller with a 24” hot zone. Charge size was 140 kg. Heat shield was employed to obtain faster pull speeds. Cusp magnetic filed was applied to control axial oxygen profile.

Results and Discussion

1. Growth and stress analysis of seed crystal

Tensile strength of silicon seed crystals with different diameter was measured at 20 °C and 500 °C. Test results are shown in Fig. 1. Tensile strength of silicon seeds is higher at 500 °C than that at 20 °C. The difference, however, is very slight. The average fracture stress is about 7000 N/cm^2. The fracture morphology shows that the fracture at both temperatures is brittle.

For safe 300 mm silicon crystal growth, a new type seed and seed chuck have been designed. This design greatly improves the lifetime of a seed crystal. No neck breakage occurred.

2. Oxygen control

By applying CUSP magnetic filed, modification of heat shield and other hot zone components, controlling the gas flow and applying appropriate rotation rates of crucible and crystal, oxygen concentration were controlled to 28-23 ppma. Fig. 2 shows some typical oxygen concentration profiles.

3. Crystal pull speed and COP profile

High pull speed makes more COPs of small size than low pull speed does, which is consistent with results reported in other papers (2). Fig. 3 shows axial COP profiles for different sizes. There is no COP with size over 0.2 μm. Only 1 or 2 COPs with size between 0.15–0.2 μm have been detected. However, quite amount of COPs with sizes from 0.10–0.15 μm and less than 0.10 μm have been observed. The seed portion of the crystal about 300 mm in length has fewer COPs than the tail portion of the crystal. The center of a wafer has higher COP concentration than the edge of the wafer.

4. Convection control in large volume melt

During 300 mm crystal growth in a 24” hot zone, low rotation rates have been used to balance the relationship of natural and forced convection in the melt. Typical crystal rotation is 5–14 rpm while crucible rotation is 6–12 rpm. Radial resistivity gradient (RRG) of less than 5% has been obtained under the present growth conditions.

Conclusions

Tensile strength of silicon seed was slightly higher at 500 °C. With newly designed 24” hot zone and configuration of heat shield, 300 mm crystals were successfully and effectively produced. Oxygen concentration can be controlled within ±2.5 ppma in the range of 33~23 ppma. ORG was also under control. The obtained crystal had no COP over 0.2μm and very few COPs between 0.15-0.2μm. The number of COPs under 0.15μm was significant. No OISF ring was found.

References

1. H. Tu, Q. Zhou, G. Zhang, J. Wang et al., Microelectronic Engineering, 56, 77 (2001)
2. Hisashi Furuya, Kazuhiro Harada, Jea-Gun Park, Solid State Technology, 109, June 2001

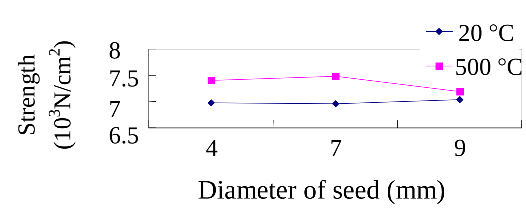

Fig. 1 Tensile strength of silicon seeds

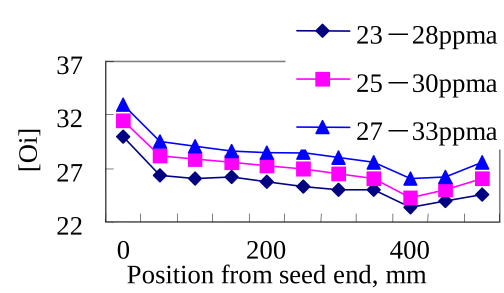

Fig. 2 Axial oxygen concentration profile

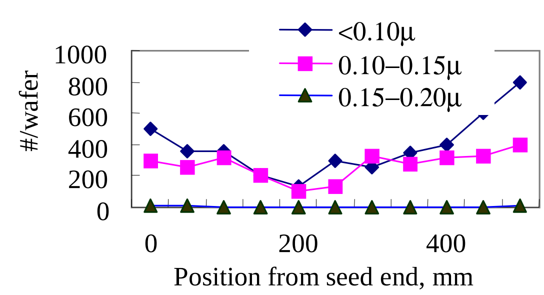

Fig. 3 Axial COPs profile for different particle sizes