Growth Technology for 200 mm
Antimony Heavily Doped Silicon
Single Crystals

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With the development new types of electronic
device devices, the demand has increased for large
diameter heavily antimony doped silicon. The atom
diameter of antimony is 15% larger than that of silicon,
resulting large lattice mismatch. The segregation
coefficient of antimony in silicon is low, making it very
difficult to obtain crystal with required resistivity. Crystal
growth 200 mm heavily doped antimony silicon with low
resistivity and high yield remains one of the toughest
challenges for the industry. This paper investigated
crystal growth process of 200 mm heavily antimony
doped silicon crystals. A new doping method was
developed. Argon flow pattern and pressure control was
modified for better process conditions.

Experimental

KX-150 crystal puller with 22” hot zone was used in
the development. Silicon charge sizes of 90-100 kg were
used. Graphite heat shield was applied.

This work designed a new quartz tool to steadily
add vapor phase antimony into silicon melt. Antimony
vapor created under high temperature flow directly onto
silicon melt surface through a specially designed quartz
mouth piece. Antimony was absorbed by silicon melt
surface and diffused into bulk melt. By controlling the
inside temperature of the quartz tool and furnace pressure,
all antimony is smoothly doped into silicon melt without
any splash. Six 9 pure antimony of 350-500 grams were
doped.

Results and Discussion

Under the same power level, different furnace
pressures resulted in different amount time needed for the
same amount dopant to evaporate. Doping completed
faster with lower furnace pressure.

Different heat shields were constructed. Under
same doping and crystal pulling conditions, heat shield I
produced crystals with increasing resistivity along crystal
growth direction. The resistivity profile was different
from that of a normal segregation coefficient of 0.023 for
antimony. Heat shield II produced crystals with
decreasing resistivity along crystal growth direction. The
resistivity profile followed a pattern resulted from a
segregation coefficient of less than 1.0. Heat shield I
forced all argon gas to flow by the silicon melt surface
while heat shield II allowed only partial argon flow to
pass by the silicon melt surface. Heat shield II greatly
reduced the impact of argon flow on antimony
evaporation. More dopant was able to incorporated into
crystal rather than evaporated.

Heat shield II produced crystals with resistivity
decreasing along growth direction. However, the
resistivity profile suggested more control over antimony
evaporation is needed even with better argon flow pattern.
Different furnace pressures were tested in efforts to lower
crystal resistivity even further. Figure 1 shows the
resistivity profile with 4 kinds of growth process. Results
showed deceleration rate of resistivity along growth
direction are different with different pressure. With
higher furnace pressure, resistivity of most portion of the
crystal was controlled under 0.02 Ωcm, achieving
requirement from most device manufacturers.

Conclusions

Vapor doping technique was feasible and effective
for heavily antimony doped silicon crystal growth. It
created better growth environment and resulted better
yield. With better hot zone design including heat shields,
along with pressure control and other optimized growth
parameters, heavily antimony doped 200 mm silicon with
resistivity less than 0.02 Ωcm can be produced with high
efficiency.