

APPLICATION NOTE

# SIMS Measurement of Bulk [N] in Nitrogen-doped Cz-Si: Long Term Precision Results

## DISCUSSION

Advanced silicon substrate products are being developed for the 90 nm node and smaller devices of the future. Nitrogen-doping during Cz-Si crystal growth is a key technology for some of these products, because this facilitates the engineering of defect properties needed for the low temperature processing at 90 nm node and smaller devices. The measurement of bulk [N] is required at the  $10^{13}$ - $10^{14}$ /cm<sup>3</sup> range for these advanced silicon substrate products.

The goal of the industry is to develop an FTIR measurement of the bulk [N], but achieving this at the required concentration range and acceptable precision is still a challenge. An ASTM F 2139 test method for the SIMS measurement was approved in 2001, but the actual precision of the measurement needed improvement and the test method was applicable only down to  $1 \times 10^{14}$ /cm<sup>3</sup>. At EAG Laboratories, we have improved the SIMS measurement

precision using the ASTM F 2139 test method and extended the detection capability into the  $1 \times 10^{13}$ /cm<sup>3</sup> levels. Here we present long term (20 months) precision results for three levels of nitrogen in silicon. Table 1 shows the relative one standard deviation (RSD) for each level. Figure 1 shows the long term trend chart for nitrogen concentrations of  $1.7 \times 10^{14}$ /cm<sup>3</sup>,  $7.3 \times 10^{13}$ /cm<sup>3</sup>, and  $4.1 \times 10^{13}$ /cm<sup>3</sup>. These results show the excellent capability of our SIMS to make this measurement which can be used to calibrate reference materials for FTIR research and development, and to monitor crystal growth processes until the FTIR measurement development is successful.

| Sample | Average [N]                           | RSD |
|--------|---------------------------------------|-----|
| X      | $1.7 \times 10^{14}$ /cm <sup>3</sup> | 7%  |
| Y      | $7.3 \times 10^{13}$ /cm <sup>3</sup> | 19% |
| Z      | $4.1 \times 10^{13}$ /cm <sup>3</sup> | 26% |

Table 1: Long term RSDs for three levels of [N]

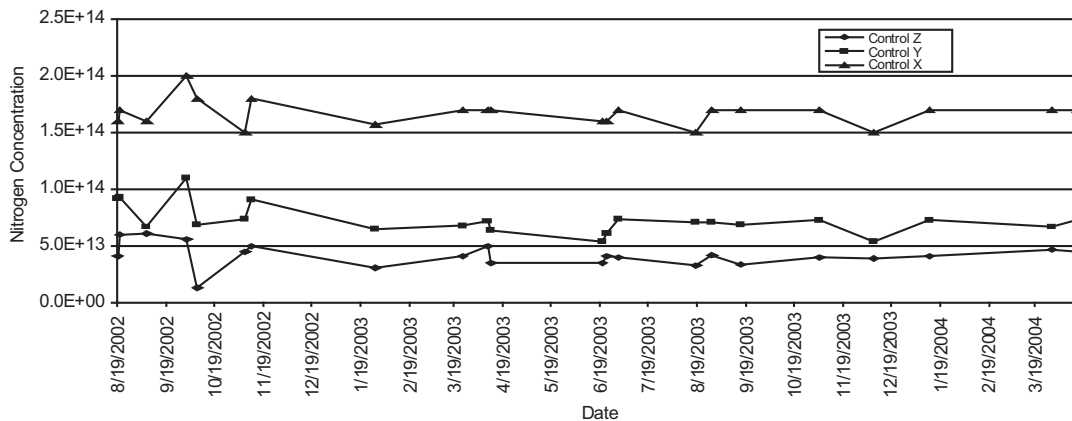


Figure 1: Long term (20 months) repeat measurements for Samples X, Y and Z.