Calculation of Size Distribution of Void Defect in Czochralski Silicon

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A simulation model, which calculates the size distribution of void defects after crystal growth, was developed. Using the calculated concentration of point defects (1), this model starts the calculation of void nucleation and its growth at the temperature below than 1150^{o}C. Figure 1 shows the comparison of calculated results with experiments. The three solid lines indicate the calculated size distribution of void defect. It was found that with an increase in the growth rate, the void size decreases and the density increases from the experimental results. The calculated peak-sizes of voids were approximately 175, 120 and 70 nm for the pulling rates of fp(A), fp(B) and fp(C), respectively (fp(A)<fp(B)<fp(C)). These results agree well with experimental results by OPP quantitatively. This model can calculate the thickness of oxide film which is formed at inner wall of void defect. Figure 2 shows the oxide thickness measured by TEM observation (2). From the experimental data of the quenched crystal, final thickness of oxide becomes 1-4 nm. On the other hand, when the crystal is halted at between 1100-950^{o}C, the very thick oxide films, up to 22 nm, are formed. Our model also can predict the oxide thickness with high accuracy. Figure 3 shows the size distribution of void defect in N doped crystal. The concentration of N is 1x10^{14} /cm^{3}. The growth rate fp(B) coincide with fp(B) in Fig. 1. It was found that the peak-size decreases and the density increases by N doping in the case of same growth rate. The solid and dashed lines indicate the calculated size distribution for various diffusion constant of vacancy. When the diffusion constant is 0.4Dv (3), the experiment and calculation agree very well. By considering the stress effect of dopants to the point defect concentrations (4), our simulation model can be adapted to the highly B doped p+ and P, As, Sb doped n+ crystals.

References

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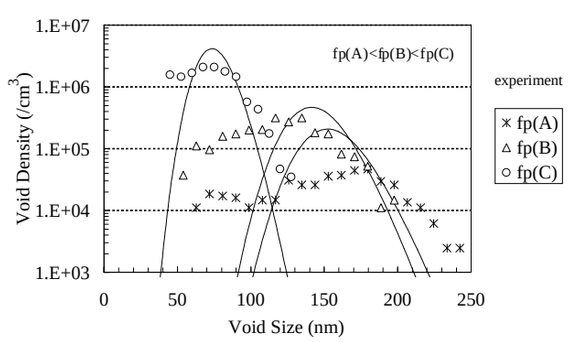

Figure 1. Size distribution of void defect in 200 mm wafers with different growth rate.

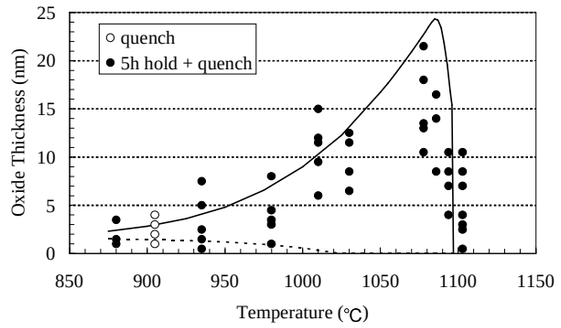

Figure 2. Oxide thickness in quenched or quenched followed by halted for 5 h.

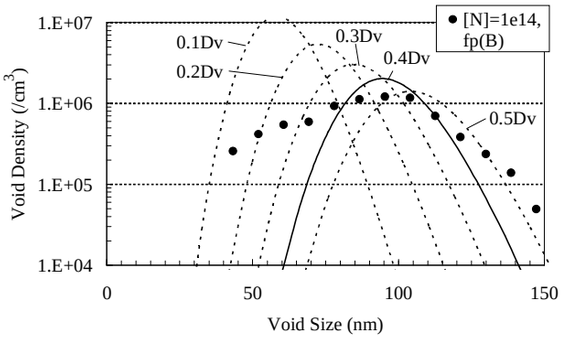

Figure 3. Change of size distribution of void defect when the diffusion constant was changed by doping of N.