CHAPTER-8
CHAPTER 8

SUMMARY CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

8.1 Diffusion of Boron in plain silicon

Simple one-dimensional theory was earlier used to model diffusion of commonly used impurities in silicon. It has however been observed that the experimentally observed profiles seldom agree with the theoretically predicted ones for concentrations higher than intrinsic carrier concentrations. Many deviations and anomalies have been observed, reported and analyzed by several workers. In the case of diffusion of boron in plain silicon, these anomalies change the profile shapes drastically making the simple one dimensional theory unrealistic. The work of a large number of workers in the field has resulted in the presentation of a large number of models for diffusion of impurities in silicon. A thorough study of various models has been made. Some of the proposed models have been selected for detailed study and actual computer program for them have been written. It has further been observed that in the case of diffusion of boron through patterned silicon, the impurity diffusion is influenced by the presence of oxide surrounding a diffusion window and has been chosen for detailed study.
8.2 Diffusion of Boron into Silicon with Oxide Masking

The use of oxide masking is a key factor in the silicon semiconductor device fabrication. The purpose of oxide is to mask against the diffusion of various impurities, e.g. boron, phosphorous and arsenic, etc. Ideally, therefore, the oxide should not interfere with the diffusion of impurities into silicon. It was, however, observed experimentally that in the case of boron, the sheet resistance obtained from the measurements made on diffused resistors ($\rho_{sm}$), was consistently greater than the sheet resistance measured on a large sheet with the help of the 4-point probe method $\rho_{sp}$. The detailed study suggested that the observed discrepancy was not due to experimental errors associated with the measurements but was a real indication of a lower doping in the boron diffused resistors. It was therefore concluded that the presence of oxide surrounding the diffusion window affects the diffusion of boron into silicon.

8.3 The Diffusion of Boron into Silicon with Nitride Masking

The use of silicon nitride as the mask against the diffusion of boron into silicon has also been studied. The results are summarised below:

(1) The use of silicon nitride as the masking material in place of $\text{SiO}_2$ does not produce any discrepancy between $\rho_{sp}$ and $\rho_{sm}$ after boron deposition.
(2) A film of oxide on silicon nitride does produce a discrepancy between $\rho_{sp}$ and $\rho_{sm}$ after boron deposition.

(3) If the surface of the masking oxide is covered by silicon nitride, the discrepancy after deposition reduces to a small value of about 6.5%.

(4) A small width of oxide left uncovered by nitride is enough to cause a discrepancy of about 14% between $\rho_{sp}$ and $\rho_{sm}$.

(5) If the oxide is doped with boron, the discrepancy between $\rho_{sp}$ and $\rho_{sm}$ after boron deposition disappears.

On the basis of the results of the experiment performed, it is suggested that most of the experimental observations may be explained with the help of a theoretical model based on 'Surface-diffusion' of boron over silicon and silicon dioxide.

8.4 The Surface Diffusion Model

An attempt is made to present a theoretical model based on the surface diffusion of boron over silicon and silicon dioxide. The model assumes a high solubility of boron in oxide and a high surface diffusion coefficient of boron over silicon. It is suggested due to high solubility of boron in oxide, the concentration over oxide surface is reduced which
results in a concentration gradient near the oxide edge. The surface diffusion of boron then takes place under the influence of this concentration gradient thereby removing some of the boron from the silicon window.

In order to test the capability of the suggested theory to explain the experimental results, simple kinetics have been assumed to describe the mechanism involved. The required data are selected to provide a reasonable fit to the experimental results.

Numerical calculations are made, initially, with a very simple steady - state model. The model, after a few successive improvements, is found to be capable of quantitatively explaining most of the experimental results.

8.5 Suggestions for Future Work

(1) A complete two or three dimensional model may be developed to consider surface diffusion and bulk diffusion simultaneously.

(2) The profiles obtained from the theoretical analysis may further be analysed for drive-in with the help of the existing models. It would be interesting to see if the results agree with experimental observations.

(3) Experimental work to extract various parameters eg. Ds, Dox, CL, Fn, G, DB etc.