CHAPTER-1
CHAPTER 1
INTRODUCTION

The fabrication of a planar silicon bipolar transistor involves a sequence of steps which selectively change the electrical properties of the starting material. These steps for a typical n-p-n transistor are shown in figure 1-1. The polished, clean, n-type, uniformly doped (typically $10^{15}$-$10^{16}$ atoms/cm$^3$), silicon wafers are first oxidised to form a thin layer (typically 0.5 μm) of silicon dioxide at the wafer surface. The oxide is then selectively etched to open windows in the regions where transistor bases are to be formed. The dimensions of these windows are of the order of several tens of microns. The base dopant, usually boron is then diffused through these windows to form a p-n junction in silicon. During diffusion, a layer of oxide is grown over the windows. The emitter regions are then defined by opening yet smaller windows in the oxide. The emitter dopant, usually phosphorus, is then diffused through these regions. The n-type wafer itself forms the collector of the transistor. To make contact with various regions, windows are opened in the oxide, aluminium is then evaporated and a contact pattern is etched out.

In order to monitor the diffusion steps, the most common and convenient method is to put 'check' slices along with the wafers during each diffusion step. Four-point probe
Fig. 1.1 Fabrication Sequence of n-p-n- Silicon Planar Transistor
measurements are then made on these check slices to give sheet resistivity after each step. The sheet resistivity thus obtained is a measure of the total number of impurities per unit area of the diffused layer formed.

One of the key features of the above process is to define precisely the regions in which various impurities are to be diffused and to mask off the other regions against the diffusion of these impurities. Luckily, the silicon dioxide acts as an effective mask against the diffusion of commonly used impurities, e.g., Boron, Phosphorus, Arsenic, etc. The reason is an order of magnitude slower rate of diffusion of these impurities through the oxide compared to that into the silicon.

The Bipolar junction transistor is the basic device in any integrated circuit. The properties of the transistor play a dominant role in the determination of circuit performance of any IC. The transistor characteristic is controlled by impurity profiles which in turn depends upon process parameters.

As a result of this, a complete understanding of various fabrication steps is becoming more and more important. In particular, the rapid advancement in the fields of LSI/VLSI technology and the resulting complexities greatly enhance the need of proper modelling and simulation.
of the fabrication processes. Various models developed so far do not give satisfactory results in all cases of practical interest and are, therefore, of limited usefulness. As a result of this even the most advanced technologies of IC fabrication rely heavily on trial and error. Various workers in the area of solid state device fabrication have been working since long to develop accurate process models.

Simple one-dimensional diffusion 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 diffusion theory unrealistic. The work of a large number of workers in the field has resulted in the presentation of a number of models for diffusion of impurities in silicon.

Boron being a universal dopant for p-type doping in silicon, has been selected. 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 case of diffusion of boron through patterned silicon, the impurity diffusion is influenced by the presence of oxide surrounding a diffusion window. This is a relatively unnoticed effect and has therefore been chosen for detailed study. An attempt has been made to develop a theory for explaining the observed effects. This has been done on the basis of a carefully designed series of experiments. A comprehensive software has been developed for determining impurity profiles of boron in silicon taking almost all the known anomalies and effects into account including the effect of masking oxide.