The study of non-crystalline materials is an active area of research in solid state physics mainly because of the enormous and diverse applications of these materials like xerography, memory and switching elements and energy conversion devices such as solar cells. They differ from their crystalline counterparts by the absence of long range order. Their interesting electrical, optical and magnetic properties along with the wide flexibility in preparation and composition make them unique in several applications. Like crystalline materials, non-crystalline materials can be ionic, covalent, metallic or van der Waals' bonded materials. Consequently, they can be insulating, semiconducting or metallic in nature.

Amorphous semiconductors can be generally classified into two groups as tetrahedrally coordinated semiconductors like a-Si, a-Ge etc and chalcogenide semiconductors like Ge-Se, As-Se etc. Chalcogenide glasses contain one or more of the chalcogen elements, S, Se or Te of the sixth group of the periodic table. The four-fold coordination in Si leads to symmetrical bonding and the formation of rigid structures, while the two-fold coordination in chalcogens is highly asymmetrical and the structure gives rise to greater degree of flexibility for interatomic bonds. Like other glassy solids, these
materials also possess only short-range order and because of this, the theories developed for crystalline materials cannot directly be applied to them.

Chalcogenide glasses form an important class of amorphous solids. They have very interesting physical properties and can be prepared in the bulk as well as thin film forms. One of the greatest advantages of these glasses is the composition dependent tunability of their properties, which enables one to design materials for specific requirements. They have potential technological applications such as materials for threshold and memory switching, inorganic photoresist, xerography, IR detection and transmission etc. These materials are suitable for IR optical elements such as cell windows and prisms and as FIR beam condensers, splitters and other accessories, since they do not absorb IR radiation. Many of these glasses can be formed by the conventional melt quenching technique over a wide composition range making them suitable model systems for systematic studies on composition dependent properties.

In order to explain the features observed in the composition dependence of various properties of chalcogenide glasses, various models like random network models and topological models have been proposed. According to the chemically ordered covalent network (COCN) model, heteropolar bonding is maximized, thereby favouring chemical order. Topological models use the concept of average coordination number $Z$ and interpret the properties of chalcogenide glasses in terms of $Z$. 

ii
We have selected silicon as a representative of the family of tetrahedrally co-ordinated materials and the glass systems Ge$_{100-x}$Se$_x$ (5 ≤ x ≤ 40) and As$_x$Se$_{100-x}$ (10 ≤ x ≤ 60) as representatives of the class of chalcogenides for our studies. For most of the device applications, chalcogenide materials are used in the form of thin films. The optical properties of thin films are sensitive to many parameters including their thickness and hence can provide important information on both device and materials characteristics. In this context, we have carried out the optical characterization of the thin film samples of the systems Ge-Se and As-Se, which includes the determination of their optical band gaps and refractive indices. For the preparation of thin films, we have also designed and fabricated a vacuum coating unit capable of creating ultimate pressures of about 10$^{-5}$ Torr.

It has long been known that intrinsic chalcogenide glasses behave like p-type semiconductors and are insensitive to doping in small amounts. This behaviour is attributed to the local valence saturation of the dopant atoms. Fermi level is considered to be pinned due to the equilibrium between positively and negatively charged defect states, known as valence alternation pairs (VAPs). The presence of a large number of defect states in the band gap makes them normally insensitive to impurity doping. Incorporation of impurities into a semiconductor by high-energy ions is a non-equilibrium process which can result in intriguing property changes in the material. The ion-solid interaction process can lead to the modification of the composition,
structure, electronic properties and topography of the semiconductor. Ion implantation is a key technology for the fabrication of doped layers in silicon semiconductor microelectronic devices. In this context, we have carried out a study of modification effects in the two classes of materials of amorphous semiconductors by the technique of ion implantation. Optical absorption measurements in these samples have been carried out by Photothermal Deflection Spectroscopy (PDS), a highly sensitive technique which allows the detection of low levels of absorption, typical of the subgap region of semiconductors.

During the past few years, thermal wave physics has emerged as a valuable tool for the characterization and analysis of the material parameters. The determination of thermal parameters is an important method for characterizing materials. Thermal diffusivity is an important thermo-physical parameter which is of direct importance in heat flow studies as it determines the rate of periodic or transient heat propagation through a medium. Its determination is often necessary because of its controlling effect and common occurrence in thermal conduction problems. Based on these lines, we have carried out the thermal diffusivity measurements on the thin films of the systems Ge-Se and As-Se using PBD technique.

The thesis is divided into seven chapters. In the first chapter, an overall
review of amorphous semiconductors is given. It includes an introduction to amorphous semiconductors, followed by a brief discussion on the important structural models proposed for chalcogenide glasses and their electrical, optical and thermal properties. The chapter also gives a brief description of the Physics of thin films, ion implantation and photothermal effects.

Chapter 2 presents a description of the experimental techniques used in the present investigation. A brief description of the experimental set up of a photothermal deflection spectrometer is given, followed by the illustration of the design and fabrication of a vacuum coating unit which is employed for the preparation of thin films in our studies. The chapter includes the details of the preparation of the samples and also the description of the UV-Vis-NIR spectrophotometer used for the optical characterisation of the thin film samples under investigation.

Chapter 3 gives the details of the preparation and optical characterisation of the thin film samples of the systems Ge$_x$Se$_{100-x}$ (5 ≤ x ≤ 40) and As$_x$Se$_{100-x}$ (10 ≤ x ≤ 60). The absorption and transmission spectra of these samples are analysed. From the absorption spectra, the optical band gaps are determined. The variation of optical band gap of these samples with composition is investigated and the observed behaviour is explained on the basis of various models. A simple calculation following traditional methods has been employed for deducing the refractive indices of the samples from the
fringe pattern of the transmission spectra and the variation of refractive index with wavelength for different compositions of the samples is also investigated.

Chapter 4 deals with the employment of the subgap optical absorption measurement by PDS to characterize the defects, amorphization and annealing behaviour in silicon implanted with B+ ions. The effect of ion dose, implantation temperature and thermal annealing on the subgap absorption are investigated. The chapter also presents the profiles of the ion range and vacancy distribution obtained by the TRIM simulation. The changes induced in the band edge slopes and in the subgap features of the spectra are described. The various stages of formation, quenching and annealing of divacancies are monitored as a function of implantation conditions and annealing cycles. The chapter also describes the investigations on the structural modifications and defect evolution under annealing in amorphous material produced by implantation.

Chapter 5 outlines the results of thermal diffusivity measurements of the thin film samples of the glass systems Ge$_x$Se$_{100-x}$ (5 ≤ x ≤ 40) and As$_x$Se$_{100-x}$ (10 ≤ x ≤ 60) using PBD technique. For this, we have adopted the phase method, making use of the tangential (parallel) component of deflection signal based on the skimming configuration, where the probe beam grazes the sample surface. The experiment has been performed for two different modulation frequencies and the results are verified using the amplitude method. The variation of thermal diffusivity with composition for the two sets of samples has also been
investigated and explained on the basis of structural changes taking place in the glass network with the change in composition.

Chapter 6 reports the results of the optical absorption measurements by PDS in nitrogen implanted thin film samples of Ge-Se and As-Se systems. The profiles of the ion range and vacancy distribution are obtained by the TRIM simulation. The variations of optical band gap and inverse logarithmic slope with implantation for the different compositions of the samples are investigated and are explained on the basis of structural changes taking place in the network due to ion bombardment.

Chapter 7 is the concluding chapter incorporating overall conclusions of the work presented in earlier chapters. Further scopes for the work that can be done in this direction on other chalcogenide glass systems are also discussed.