Chapter 6

Summary

The physics and technological applications of semiconductor nanostructures have been the subject of intense research interest for about thirty years. In fact, it might be described as one of the earliest areas of mainstream nanoscience/nanotechnology. Semiconductor nanostructures are structures in which, by means of novel crystal growth or processing techniques, the dimensions of structure are on the nanoscale in one or more dimensions. Charge transport in any semiconductor nanoscale device is characterized by the charge carrier scattering by impurity, phonons, and crystal defects or with other carriers. Electron scattering by acoustic phonons plays a key role in the physics of semiconductor nanostructures and their potential applications. Acoustic- phonon scattering controls the relaxation of carriers to their band bottoms, which is necessary for efficient laser action, for optical modulation and for other optical and transport phenomena. Great efforts have been made to investigate the scattering rates in low dimensional systems and have been shown that the confinement play an important role on electron-phonon scattering in the systems of reduced dimensionality.

In the present work, the carrier scattering rate and other transport properties are studied under the effect of different parameters like temperature, electric and magnetic fields, etc. Electron momentum relaxation times, energy relaxation time, drift velocity, resistivity, energy loss rate by means of phonon absorption and emission and power loss

etc. are determined with the analogy of electron phonon interaction. There are several types of carrier scattering mechanisms like electron – electron scattering, ionized impurity scattering which are discussed in detail for bulk case [**Chapter 2**] from which we consider the most dominant one of the concern of present thesis. The carrier transport properties are carried out for two dimensional diluted nitride semiconductors (e.g. $GaAs_{1-x}N_x$) and diluted magnetic semiconductor (DMS) (e.g. $Ga_{1-x}Mn_xN$) via deformation potential coupling mechanism. We consider inter-subband scattering which is induced by the ADP scattering in which the acoustic phonons carry little energy, so an electric field accelerates carriers to energies exceeding the bottom of the next subband before scattering to a higher subband [**Chapter 3**].

Since the major aspect of the present thesis is to study the electron transport in nanostructures, the transport under the effect of different parameters like electric and magnetic fields is also considered. It is observed that whenever the devices are operated under high electric fields the electron mean energy and their average momentum acquired increase with the electric fields. The study of carrier interaction under the effect of electric field is of considerable interests and carried out in the present thesis. We discuss the electron transport phenomena under the influence of electric field to understand the operation and performance of many heterostructure devices under high electric field. The variation of electron scattering rates (e.g. momentum and energy relaxation rates), carrier drift velocity and mobility, electron energy loss rate by means of phonon emission and phonon absorption with respect to electric field and doping concentration are considered. The relaxation rates for hot electrons decrease exponentially with high electric fields under applied magnetic field but increase with magnetic field is also observed. It is revealed from the study that as the field increases, the electron drift velocity also increases but decreases with nitrogen concentration. The energy relaxation rate decreases with field but increases with nitrogen doping. It can be concluded that the energy acquired by electron from field is absorbed for emission of phonons of energy $\hbar\omega_{LO}$ but this energy is concentration dependent so as the electric field increases the ratio of energy gain to energy absorbed increase with the electric field but the optical phonon energy $\hbar\omega_{LO}$ increases for nitrogen concentration in $GaAs_{1-x}N_x$. The energy relaxation rate depends on the emitted optical phonons and the momentum relaxation rate [**Chapter 4**].

It is the well known fact that the functionality of modern semiconductor devices relies on the control of electronic charge. However, the carriers do not only carry charge, but also spin. Spin transport has one major advantage compared to charge transport: quantum coherence can be maintained on much larger time scales. *Spintronics* (or spin-based electronics), also known as magnetoelectronics, is an emergent technology which exploits the quantum spin states of electrons as well as making use of their charge state. Several device applications, such as spin transistors, spin memory, and also the spin quantum computer have been proposed to utilize spin dependent effects in semiconductors. So far, the only commercial applications utilizing spin dependent transport (e.g. read heads for magnetic hard disk drives) rely on the giant magneto-resistance in metals. However, only the control of spin in semiconductors together with modern semiconductor technology can lead to widespread applications. In **Chapter 5** of the present thesis, we tried to calculate spin relaxation rate and by doing this we put one step ahead to understand the procedure of spin flip and hence improve the technology toward the mechanism of more little and fast memory storing devices. We have shown that the scattering by acoustic phonons via deformation potential leads to the experimentally observed behaviour of the **Spin Relaxation Time** for electrons in quantum wells , in which reasonable thin widths result in temperature independent measurements , while for thicker wells an untypical temperature dependence shows up , as a transition to a three -dimensional behavior.

Briefly, one can conclude about the present thesis that the work is related to electron transport through the nanostructure devices of diluted nitride and diluted magnetic semiconductors under the effect of different parameters.