CHAPTER 7

Conclusions

The present thesis is devoted to the studies of the transport properties of the two dimensional hole gas in semiconductor heterojunctions and quantum wells. In this connection the theory of scattering and mobility calculation of holes in GaAs - AlGaAs heterojunction has been developed with special emphasis on thermoelectric properties as well. The studies of the transport properties of the two dimensional hole gas confined in an AlGaAs-GaAs heterojunction have been done in order to address the anomaly in the effective mass values of light and heavy holes. The discrepancy between the theoretical and experimental effective masses has been resolved by comparing the theoretical mobility values computed using two different sets of effective masses available in reviewed literature with the experimentally available mobility values given in published results. It is found that background impurity scattering is the dominant mechanism limiting the mobility at low temperatures below 30K. Deformation potential acoustic phonon scattering and piezoelectric scattering are also important in the range 40-90K. But contrary to earlier results, piezoelectric scattering seems to dominate over deformation potential acoustic phonon scattering according to the present theory. Polar optic phonon scattering is dominant at still higher temperatures.

The thermoelectric power (both diffusion and phonon drag) have been estimated for the above structure with a view to having an idea about the hole-phonon coupling. In the calculation of diffusion thermopower, only background impurity scattering has been considered as it is the dominant mechanism at low temperatures. The temperature variation of diffusion thermopower has been studied in order to have an insight into the low temperature scattering mechanism operative. In order to understand the hole-phonon coupling, phonon drag thermopower calculation is very important.
thermopower has been calculated using a simple formula for both deformation potential acoustic phonon scattering and piezoelectric scattering. Contribution of piezoelectric scattering to phonon drag thermopower is more than the contribution due to the deformation potential acoustic phonon scattering. There is a discrepancy in the value of the deformation potential constant in the available literature. The value of this constant is less for holes than the electrons. However, taking the wide range of values available, it is found that piezoelectric scattering has the larger contribution. Phonon drag thermopower depends to a large extent on the phonon mean free path, which is very sensitive to temperature. Hence the dependence of phonon drag thermopower on phonon mean free path has also been studied. The phonon drag thermopower is found to be more pronounced than diffusion thermopower.

In this thesis, the capacitance-voltage profiles of a Si-SiGe-Si single quantum well structure have been studied. Anomaly between the existing theory and experimental results available have been explained using a quasi two-dimensional quantum mechanical model. The variation of carrier concentration in the well with field at different temperatures has also been studied. The simulated profiles are similar to the experimentally obtained profiles for the same structure.

A new and simple method for the determination of the conduction band offset has also been developed in this thesis. The capacitance-voltage profiles of a quantum well structure at different temperatures can be utilized for the purpose. The total charge content in the quantum well is estimated from the curves and these values are then used to match the charge content calculated from a quantum mechanical model for the same parameters and for different trial values of the band offset. The curve that best fits the experimental data gives the true value of the band offset.

Scope for further work: The transport properties of the two-dimensional hole gas present in a heterojunction have been studied here. But in reality, external
transverse fields are often superposed on the heterojunction that affect the Fermi level position inside the well, the two dimensional carrier concentration and the shape of the potential well also. This results in altered values of the variational parameter $b$ and the subband levels. This must have some effect on the lateral mobility of the carriers however indirectly it may be. It is worthwhile to study the effect of the transverse field on the lateral mobility of the carriers.

The study of thermoelectric power done in this thesis can be further extended if reliable experimental data are available. By comparing the theoretical results with the experimental values, the anomaly in the value of the deformation potential constant may be resolved. Further, some idea about the value of the phonon mean free path and its variation with temperature may be estimated from the experimental results. Studies of thermomagnetic effects may also prove to be an interesting problem.

The characterization studies done here are more appropriate for a narrow well. The theory may be modified and made suitable for appropriate C-V profiling in quantum structures. This holds future scope for further study and improvement. The new method proposed for the determination of the conduction band offsets may be applied directly for the determination of valence band offsets in heterostructures where the valence band offset is a larger fraction of the total band offset.