CHAPTER-10

CONCLUSION

This thesis deals with the transport and thermoelectric properties of low-dimensional hole-gas present in two promising heterostructures, viz the symmetrically doped Si-SiGe-Si quantum-well and the GaAs-AlGaAs rectangular quantum-well wire.

A suitable wave-function has been proposed to account for the well-width dependent hole distribution in the Si-SiGe-Si symmetric quantum well. The transport parameter i.e., mobility, is computed with the help of the new wave function and the results are compared with experiment. The suitability of the proposed wave-function as compared to the already existing wave functions like the Fang Howard and the Sinusoidal distributions has also been evaluated. The energy values of the subband have also been calculated. From these studies, it may be concluded that the proposed wave function accounts well for the two-dimensional hole distribution in a symmetrically doped Si-SiGe-Si quantum well at lower temperatures for all well widths. The temperature variation of mobility has been studied for different scattering processes and compared with experimental data. The relative contributions of the scattering mechanisms reveal that alloy scattering is the most dominant phenomenon at lower temperatures. It is followed by surface roughness and impurity scattering in that order. However, surface roughness scattering is important for very wide or very narrow wells and becomes insignificant at intermediate well-widths. At all alloy thicknesses, acoustic phonon scattering is not very important. The carrier concentrations however has its effect on the different scattering processes. Surface-roughness scattering increases with increasing two-dimensional carrier concentration. The Fang-Howard wave function approximates the new-wave function for wider well >40nm and the Sinusoidal wave function is the limiting case for narrow wells <10nm. For intermediate well widths, the new function cannot be approximated by any conventional wave function. For all well widths, this wave function explains experimental data satisfactorily for lower temperatures. For temperatures above 77K, higher subbands start getting populated and this new wave function valid for the lowest subband is
not sufficient. For lower temperatures, the proposed wave function helps in computing the subband energy. When employed to compute thermoelectric power at different temperatures, the temperature variation of thermopower of 2DHG present in the first heavy hole subband of a symmetrically doped Si-SiGe-Si quantum well shows the usual trend.

It has been proposed by many research workers that the effective mass of holes in heterostructures are dependent on the dimensionality of the carriers. In a suitably grown quantum wire of GaAs-AlGaAs pair the 1D hole effective mass becomes very low. The mobility of 1D holes in a rectangular quantum-wire of GaAs-AlGaAs system has been computed taking into account the modified effective mass. The mobility of 1D holes in such a quantum wire is found to increase over the mobility of 2D holes in a quantum well or heterojunction. Impurity scattering dominates below 50K while polar optic phonon scattering comes into play above 50K. The acoustic phonon scattering is computed using both elastic and inelastic approximations. The mobilities for the assumption of inelastic scattering are lower than the elastic scattering approximations. But in both the cases, the 1D hole mobilities become comparable to those of one-dimensional electrons present in a similar structure. The performance of 1D hole gas is superior to that of 2D hole gas when compared with the corresponding electron gases. Thermoelectric power variation of the one-dimensional holes with temperature is linear at lower temperatures.

The screening effects of 2DHG and 1DHG have been studied as they offer excellent models for the study of many body effects in physics. The screening effect dominates more in two-dimensional hole gas than in the one-dimensional system. The electron phonon coupling is weakest in 2DHG.