Chapter 1
Introduction

Theoretical and experimental investigation of heavily doped strongly compensated semiconductors (HDCS) [9,18,20,40] have made considerable progress in semiconductor technology. HDCS are used in many electronic devices for example, thermoelectric devices, lasers, semiconductor, etc. Generally, HDCS consists of ionized donors and acceptors of nearly equal concentration and a small number of localized electrons which occupy the lowest energy states in the gap.

The band structure of impure semiconductors [6,17] has been extensively studied in three dimensional screened Coulomb potential to give the asymptotic form of the density of states. To calculate the density of states (DOS) one solves for an exact expression for the average propagator of a completely disordered system [1,2,5,15,16,22,25,41], which is evaluated by using a method of expansion in terms of cumulants defined over the Feynman path integral [8]. In the regions of deep narrow potential wells, the electrons will be highly localized. The localized energy levels in the band gap are the band tails of density of states.

The density of states in the tail is calculated for GaAs [40]. It is clear that this approach predicts tails which are identical on conduction and valence band tails [12,14,30,33,34,36,37]. The density of states is expressed with the energy function of the preexponential factor $A(E)$ and the exponent $B(E)$, respectively. The DOS expression is expressed as of the result of Halperin and Lax [12]. Important contribution to the potential variation near an average potential arises from fluctuations in impurity clusters whose volume is of the order of the cube of the screening length. The interaction potential is adequate to describe interacting impurities in a semiconductor if the effect of the lattice is described in the effective mass approximation.

In this thesis, Feynman's path integral method [7,8,11,25,26,32] is used to calculate the band tail DOS of a heavily doped strongly compensated semiconductor, when the screening by intrinsic carriers cannot be neglected. The calculated density of states near the tails of energy bands are very similar to the Urbach tail [38]. That is, the critical exponent n has the value between 1 and 2. This finding does not agree with the Kane theory [17].

Feynman's path integral method is based on a variational principle. The Feynman path integral involves a number of approximations which are valid in the limit of high impurity density. The results of our present calculation are the

density of states in the band tails of HDCS. The density of states is expressed in an analytic form of two dimensionless functions, the preexponential $a(v, z)$ and the exponential $b(v, z)$ [26], respectively. Moreover, numerical results $a(v, z)$ and $b(v, z)$ are very important to finding the density of states of HDCS.

The outline of this thesis is as follows: in the next chapter, we review the basic idea of Feynman's path integral theory. In Chapter 3, we review modelling of heavily doped strongly compensated semiconductors. In Chapter 4, we give in details our work and the calculation of the approximate density of states of heavily doped strongly compensated semiconductors. Finally, discussions and conclusions are presented in Chapter 5.