CHAPTER I

INTRODUCTION

1.1 Preliminary

The ratio for the diffusion coefficient D and mobility μ of the carriers with charge q of non-degenerate semiconductor at a finite temperature T is found to be $k_B T/|q|$. This is known as the Nerst-Townsand-Einstein diffusivity-mobility ratio or simply the Einstein diffusivity-mobility ratio for many decades. Other systems like doped semiconductors have also been investigated for this relation. Sometimes, various physical conditions such as temperatures, magnetic fields, band tail states, quantum size effect were taken into account. The diffusivity-mobility ratio is one important relation that leads to two thermodynamic quantities of the semiconductors. The diffusivity-mobility ratio has been expressed in general as a function of carrier concentration n and the derivative of the Fermi energy with respect to the carrier concentration.

To determine the Fermi energy of semiconductors, one needs to know the density of states of that semiconductors. The density of states of a semiconductor especially for the heavily doped semiconductors is, however, not a quantity easy to determine. The density of states of heavily doped semiconductors has been determined fairly accurately using semi-classical method which be formulated by Kane[1] . However, it has also been determined much more fairly accurately using Feynman's path integration formulated by Sa-yakanit and Glyde[2] .

Van Cong and Debiais[3] derived an empirical diffusivity-mobility ratio for any carrier concentration using a simple and accurate relation between Fermi energy and carrier concentration, based on the two correct asymptotic forms of the Fermi energy[4]. Because the empirical diffusivity-mobility ratio is strongly dependent on asymptotic behaviors of the expression of Fermi energy for any carrier concentration and using parabolic band density of states approximation, it has high accurate results in completely non-degenerate and extremely degenerate regions. However, it may give poor accurate results in moderately degenerate region (heavily doped semiconductors). This is one of many disadvantages of the empirical Einstein D/μ relation which we will explain in Chapter III .

From many disadvantages of the empirical diffusivity-mobility ratio especially in the moderately degenerate region of which band tail density of states is important, we derive an diffusivity-mobility ratio by using Kane's band tail density of states and the Thomas-Fermi approximation, valid for the moderately degenerate region to extremely degenerate region. Furthermore, we can show that diffusivity-mobility ratio, in extremely degenerate case, is the same from the empirical result.

In this study we will stress on non-compensated and slightly compensated n-type heavily doped semiconductors and gallium arsenide (GaAs) as our samples.

1.2 Outline of thesis

The purpose of this thesis is to derive the diffusivity-mobility ratio for n-type heavily doped semiconductors by using the Thomas-Fermi approximation and to compare our numerical results with the empirical diffusivity-mobility ratio. The outline of our work is as follows :

In the next chapter, we review the concept of the generalized diffusivity-mobility ratio which will be used to derive the empirical diffusivity-mobility ratio and the diffusivity-mobility ratio for n-type heavily doped semiconductors in Chapter III and IV, respectively. In Chapter V, using results from Chapters III and IV, we calculated numerical results of the diffusivity-mobility ratio. Discussion and conclusion, including suggestions, will be given in the last chapter.