Monte Carlo Simulation of Electron Transport in wurtzite Indium Nitride

C.SAYAH*, B.BOUAZZA**, A.GUEN-BOUAZZA, N.E.CHABANE-SARI

Unité de Recherche Matériaux et Energies Renouvelables, Faculté de Technologie, Université Abou-Bekr Belkaïd de Tlemcen.BP 230, Tlemcen 13000, Algérie.

ABSTRACT

Among the group-III nitrides, InN displays markedly unusual electronic transport characteristics due to its smaller effective mass, high peak velocity and high background electron concentration. We present the steady-state, velocity-field characteristics of wurtzite indium nitride, determined using an ensemble Monte Carlo approach. A three valley model for the conduction band is employed and ionized impurity, polar and non polar optical phonon, acoustic deformation potential, piezoelectric, deformation potential and intervalley scattering mechanisms are considered. The sensitivity of these steady-state results to variations in temperature and doping concentration is examined. Our results suggest that the transport characteristics of indium nitride are superior to those of gallium nitride and gallium arsenide, over a wide range of temperatures, from 77 to 600 K, and doping concentrations, up to $1.0x10^{19}\ cm^{-3}$. Hence, indium nitride has considerable potential for device applications.

Keywords- Monte Carlo method, semiconductor materials, wide bandgap semiconductors.

I. INTRODUCTION

The III-nitride-based systems in general and InN in particular have attracted a great deal of attention in recent years. These materials had been known to have wide band-gap energies (**3. 42** eV for **GaN**, **6. 2** eV for **AlN**, and **1. 89** eV for **InN**) so that they can be used for the fabrication of devices working in the blue and ultraviolet regions of the spectrum. However, there is controversy over the material parameters of InN and, according to recent studies, its band gap value is between **0. 7** eV and **0. 8** eV [1,2] with band-gap bowing of **1. 43** eV [3] In addition to the intriguing controversy about the fundamental band gap of InN, another undetermined important parameter is the effective mass m*. Effective mass plays a dominant role for transport and mobility characteristics and device design but various values have been reported for InN. The commonly used, traditional value for the effective mass is **0. 11**m_e [4] but for the band gap of **0. 7– 0. 8** eV, the effective mass is presented as $0.07m_e$ [5] and in other studies as $0.042m_e$ [6,7], where m_e is the free electron mass. A more-recent study even questions the validity of a band-gap value of about **0. 7** eV[8]. Previously commonly used parameter values for the band-gap energy, band-gap bowing, and effective mass for InN were **1. 89** eV[9], **3. 8** eV[10], and **0. 11**m_e [4], respectively. The electron transport characteristics of InN have been studied [11, 12] and during the past few years electron low-field mobilities in InN above 2000 $cm^2/V\ s$ have been measured [13, 14]. The best reported mobility of InN at room temperature was about **3500** cm^2/V **s** [15]. Recent theoretical estimates for low-field mobility with undoped InN have reached about **14, 000** $cm^2/V\ s$ at room temperature [16]. Among the III-nitride materials, InN exhibits the highest peak overshoot velocity when compared with GaN and AlN [17]. A more-recent study where the newly published material parameters for InN are used shows that the peak velocity of electrons in bulk InN increases significantly [18, 19].