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INTERFACE ROUGHNESS SCATTERING LIMITED MOBILITY IN InAs/GaSb SUPERLATTICE

Kingsuk Mandal, Aniruddha Ghosal
Institute of Radio Physics and Electronics, University of Calcutta, 92, A.P.C. Road, Kol–700009
Kingsukrpe.mtech@yahoo.com

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ABSTRACT

The authors have calculated the low temperature perpendicular and horizontal mobilities in InAs/GaSb superlattice taking into account the effect of interface-roughness scattering (IRS). From the knowledge of the vertical and horizontal relaxation rates for the IRS, obtained from the solution of the Boltzmann transport equation, the corresponding mobilities have been computed.

I. INTRODUCTION

InAs/GaSb superlattice find widespread application in infrared focal plane arrays and photodiodes [1-9]. The knowledge of horizontal and vertical mobilities in InAs/GaSb superlattice (SL) is essential in understanding the electron transport mechanics in such devices. The electron transport in InAs/GaSb superlattice is mainly limited by the interface roughness scattering (IRS) [10-11].In this light ,the authors have calculated the IRS limited mobilities both for horizontal and vertical directions in InAs/GaSb superlattice. Vertical and horizontal electron mobilities in InAs/GaSb superlattice are calculated by solving the Boltzmann transport equation using the corresponding relaxation rates from the [1].

II. ANALYTICA MODEL

For an electron distribution function f(k) the steady state Boltzmann distribution equation may be written as [9]

$$\left(\frac{\partial f}{\partial t}\right)_{\text{coll}} = \frac{e\vec{F}}{\hbar} . \nabla_k f \qquad (0)$$

where $\vec{F}$ is the applied electric field and $\nabla_k f$ represent the gradient of f with respect to k .

The authors have incorporated interface roughness scattering (IRS) in the Boltzmann transport equation. The corresponding expressions of vertical relaxation rate and horizontal relaxation rate for IRS have been used from [1] .The data of vertical relaxation rate($\tau_{\perp}$) and horizontal relaxation rate($\tau_{\parallel}$) for the interface roughness scattering (IRS) have been taken from [1].The corresponding mobilities are calculated from the following expression

$$\mu_\perp = \frac{e\tau_\perp}{m^*} \quad (1)$$

$$\mu_{||} = \frac{e\tau_{||}}{m^*} \quad (2)$$

The values of $\tau_\perp$ & $\tau_{||}$ for various GaSb layer width for the parallel $m_{||} = 0.024m_0$ have been taken from the [1].

III. RESULTS AND DISCUSSION

The mobilities are calculated from the values of vertical relaxation rate ($\tau_\perp$) and horizontal relaxation rate ($\tau_{||}$) due to interface roughness scattering (IRS) as obtained from the [1].

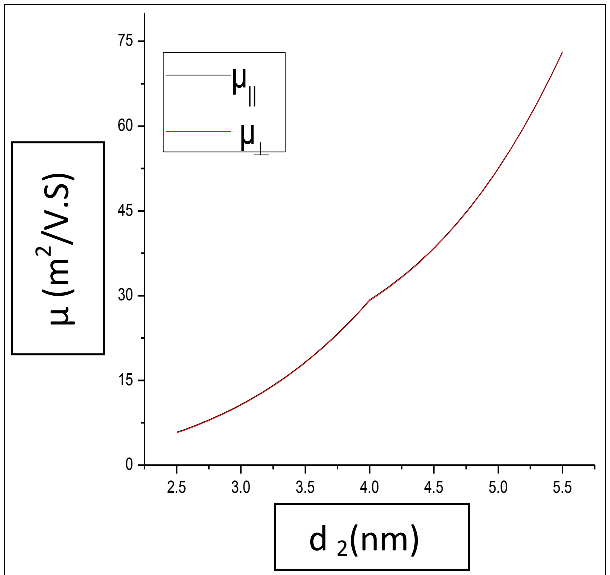

Figure 1: Variation of mobility with well width d_2 in InAs/GaSb superlattice for a short correlation length = 3nm.

The mobilities are calculated for different well widths for fixed correlation length and the results have been displayed in the Figure 1 and Figure 2. In figure 1, both vertical and horizontal mobilities are same for short correlation length, so the curves coincide with each other. In Figure 2, for long correlation length of 20nm the vertical and horizontal mobilities are different as apparent from the graphs. The vertical mobility has been found to be higher than horizontal mobility. So comparison of the two figures 1 and 2 reveals that for short correlation length the mobility is higher than that for long correlation length. It is seen from figure 2 that the vertical mobility sharply increases when the well width exceeds 4.5 nm.

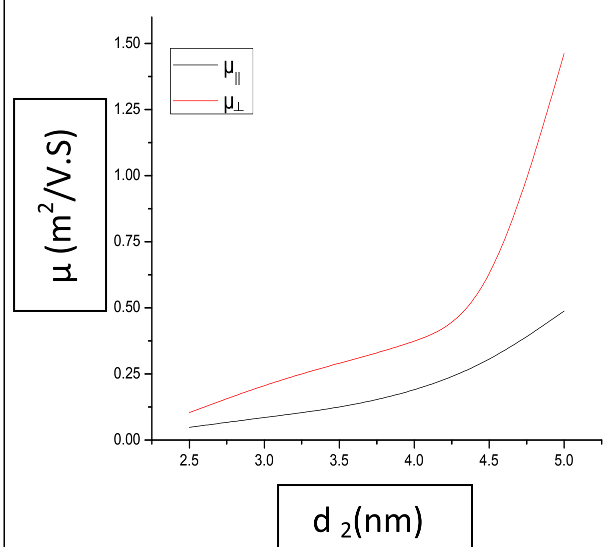

Figure 2: Variation of mobility with well width d_2 in InAs/GaSb superlattice for long correlation length = 20nm.

IV. CONCLUSION

In the present communication the authors have shown the variations of the vertical and horizontal mobilities for different well widths. For short correlation length the mobility curve is steeper as shown in fig 1.For long correlation length as seen from the fig 2 the mobility is lower compared to short correlation length as displayed in fig 1.The present theoretical investigation of mobility limited by IRS in InAs/GaSb superlattice will throw significant light in understanding the physics of the devices made with this material.

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