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Calculation of conductance for triangular multi-barrier structure in a constant electric field

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ABSTRACT

The current density expression and the unit area conductance for one-dimensional triangular multi-barrier structure in the presence of a constant electric field have been derived. For a selected range of parameters of semiconductor materials, the characteristics of unit area conductance versus the applied voltage have been investigated by the numerical calculations, and then the influence on the curve of the unit area conductance–voltage changing with the temperature, the width of the barrier and the height of the barrier have been analyzed.

1. Introduction

Superlattices are materials with narrow-band-gap posing a potential and wide-band-gap constituting a potential barrier, which are consisted of the two materials alternate growth cyclical semiconductor structures [1].

The theory of quantum effects of the potential barrier contribute a variety of new physical devices by determining the properties of different materials, different thickness of growth, doping control and the shape of a potential. Multi-barrier quantum well structure has become an important part of modern semiconductor devices. In order to design a new device and optimize the device performance, people need to understand the resonant tunneling features for the different shape of the potential

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energy multi-barrier quantum well structure. For example, Schulz and Goncalves da silva [2] and Papp et al. [3] calculated transmission coefficient and current density for the step potential barrier structure. Ohmukai [4,5] studied the quantum well structure with slope of double barrier and the relationship between transmission coefficient and structure parameters for triangle double barrier structure. Chang and Yong-Hua [6] investigated the transmission coefficient and current density for the trapezoid structure.

Since the concept of the superlattice is proposed [7] more and more investigations [8–22] have been focused on the superlattice and its properties in the electric fields with the improvement of fabrication technology, such as the preparation of superlattice technology for Molecular Beam Epitaxy (MBE) and Metal–organic Chemical Vapor Deposition (MOCVD) [23]. In recent years, many other properties have also been studied, such as the resonance transmission phenomenon [24] based on graphene for double barrier structure, the relationship between the transmission coefficient and the electronic energy and incident Angle, and the changes between electrical conductivity and the Fermi level. Bin Chen et al. [25] have studied the linear and nonlinear optical absorption for the double triangular quantum well structure. El Mouhafid and Jellal [26] has studied triangle barrier structure of the transmission properties in graphene nanobelts.

In this paper, firstly, the current density [27–29] has been calculated by the transmission coefficient of a multi-barrier structure with the incident electrons under a certain energy and wave vector. Secondly, the conductance per unit area has been deduced. Thirdly, the conductance and voltage characteristic curve and its influence have been investigated with different temperature, barrier width, and height. In the paper, the transfer matrix method [30–32] has been applied to calculate the transmission coefficient.

2. Models and theories

This article uses the model as shown in Fig. 1, in which, N and v_0 are the number and the height of potential barrier, a and $2b$ are the width of the potential well and barrier respectively. The effective

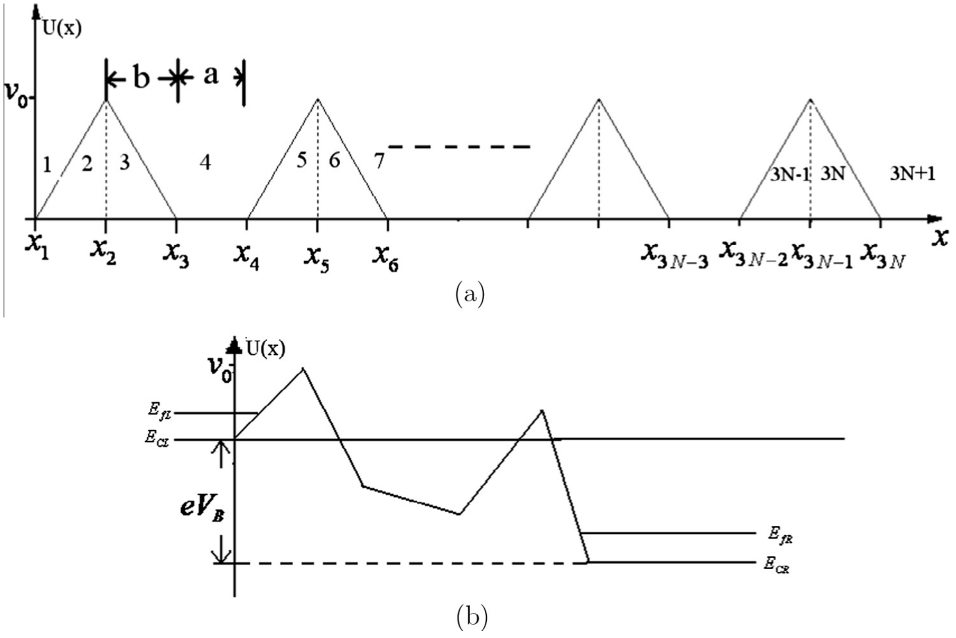

Fig. 1. (a) One dimensional triangular multi-barrier structure; (b) one dimensional triangular barrier structure in an external electric field. E_{CL}, E_{CR} are the bottom of the conduction band on the left side and on the right side, E_{fL}, E_{fR} are the Fermi energy on the left side and on the right side.