Simulation of Resonant Tunneling Structures: Origin of the *I-V* multi-peak and Plateau-like Behaviour

J. Wen, Q.C. Weng, L. Li, D.Y. Xiong*
Key Laboratory of Polar Materials and Devices, Ministry of Education, East China Normal University,
Shanghai 200241, People's Republic of China

Abstract-**Plateau-like behavior and multi-peak of the *I-V* curves of an AlAs/GaAs/AlAs double-barrier resonant tunneling diode combined with a layer of InAs QDs (QD-RTD) are simulated. Our simulation results show that the coupling between the energy level in the emitter QW (QD) and that in the central quantum well is the key point in understanding the origin of the *I-V* multi-peak and plateau-like structure. The embedded designed QD layer at the emitter spacer can enhance this effect. The effects of device temperature on the *I-V* characteristics are obtained. Our results provide the physical basis for understanding and utilizing the plateau-like behavior of *I-V* curves in designing resonant tunneling devices.**

I. INTRODUCTION

With the interest in electronic phenomena in quantum tunneling structure growing over the past two decades, the double barrier resonant tunneling structure (RTS) has been extensively studied due to its novel physical mechanism and device applications[1-6]. In this paper, plateau-like and multi-peak behaviours of the *I-V* curves of an AlAs/GaAs/AlAs double-barrier resonant tunneling diode (RTD) and that combined with a layer of InAs QDs (QD-RTD) have been simulated and analyzed in detail.

II. SIMULATION RESULTS

The samples in our experiment and simulation were grown by molecular beam epitaxy on semi-insulated GaAs (100) substrate. The material layers, from top to bottom, were piled as follows: a 50 nm highly n-doped GaAs (2×10^{18}cm^{-3}) as an emitter layer, a 150 nm *i*-GaAs spacer layer, a layer of self-assembled InAs QDs capped by 10 nm GaAs (for sample *B*), a 3 nm AlAs barrier, an 8 nm GaAs quantum well (QW), a 3 nm AlAs barrier, a 20 nm i-GaAs spacer layer and a 430 nm graded n-doped GaAs (from 1×10^{16}cm^{-3} to 1×10^{18}cm^{-3}) as a collector layer (denoted as sample A and B and showed in Figure1 and 2, respectively).

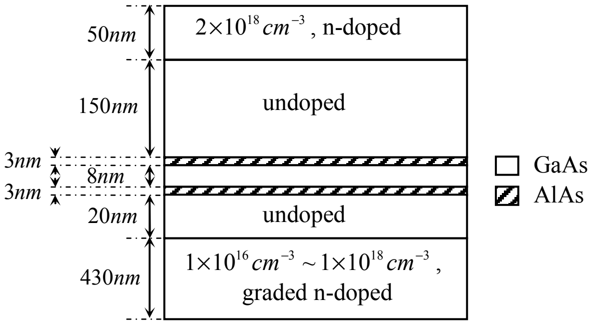

FIG.1. Structure of sample *A*

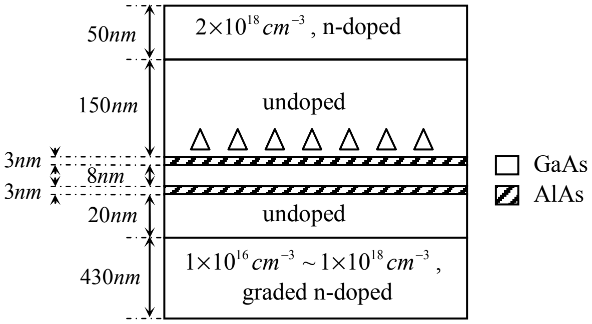

FIG.2. Structure of sample *B*

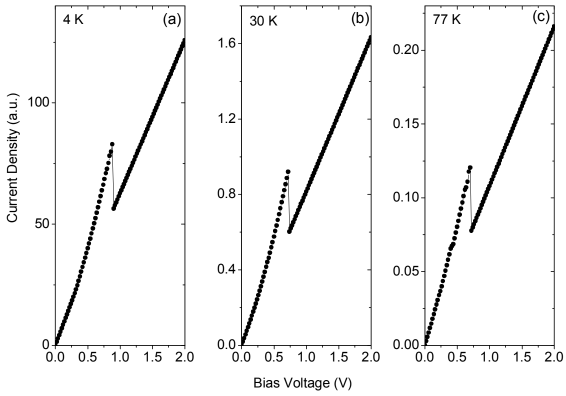

FIG. 3. Comparison of the current densities for sample *A*

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*Correspondence Email：dyxiong@ee.ecnu.edu.cn

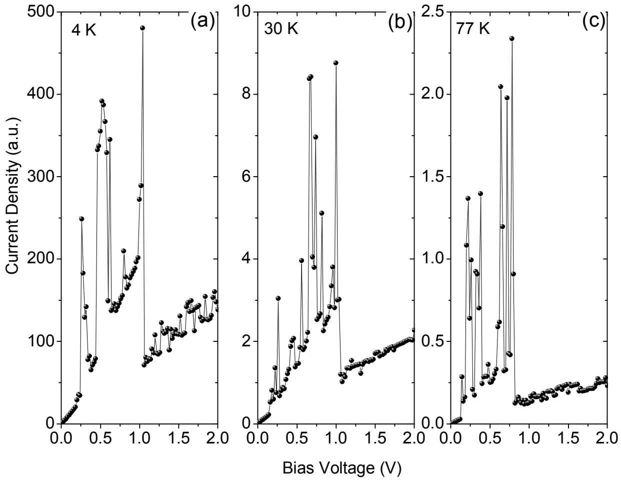

FIG. 4. Comparison of the current densities for sample *B*

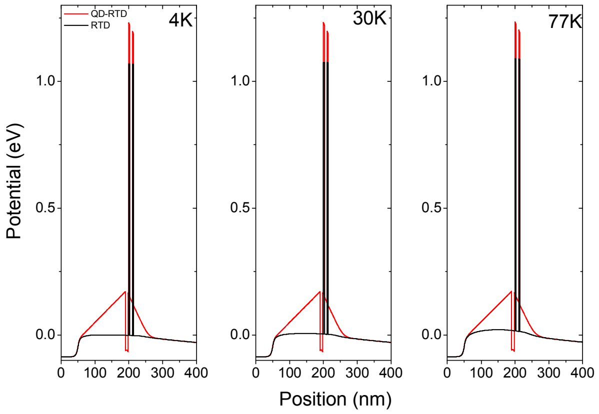

FIG. 5. Comparison of the potential between sample *A* and *B*

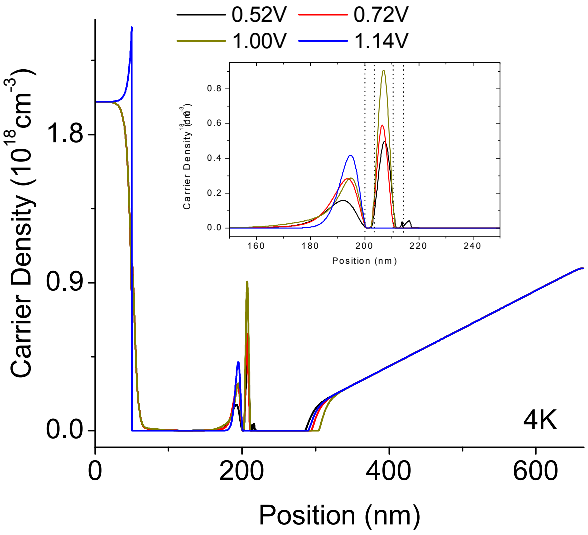

FIG. 6. Comparison of carrier density diagram of sample A at bias of 0.52V, 0.72V, 1.00V and 1.14V at 4K

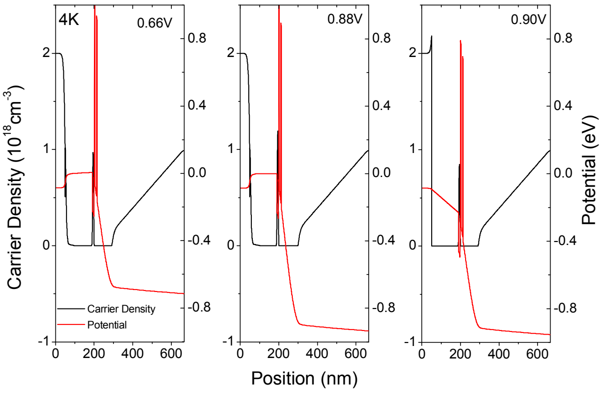

FIG. 7. Comparison of carrier density diagram of sample B with their potential diagram

The InAs QD layer has been treated as the InAs QW layer. Figure 5 indicates that the potential near the charged dots is clearly pushed up, which result in the multi-peak in *I-V* curves. The results show that the coupling between the energy level in the emitter QW (QD) and that in the central quantum well is the key point in understanding the origin of the *I-V* plateau-like and multi-peak behaviour and the embedded designed QD layer at the emitter spacer would enhance this effect. The effects of device temperature on the *I-V* characteristics are presented. The simulated results provide the physical basis for utilizing the plateau-like behavior of *I-V* curves in designing quantum resonant tunneling devices.

ACKNOWLEDGEMENTS:

This work was partially supported by the National Nature Science Foundation of China (Grant No. 61106092)

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