# Three-barrier, two-well Resonant Tunneling Structure: Photoinduced Voltage Shift Behavior

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***Abstract*-In the paper, a three-barrier, two-well resonant tunneling structure (RTS) integrated with a 1.2-μm-thick n-type GaAs layer are simulated. Our simulation results show that the coupling between the energy level in the incident well and that in the central quantum well is the key point in understanding the origin of the I-V multi-peak at reverse bias. A photoinduced voltage shift manifests that the 1.2-μm-thick, slightly doped n-GaAs layer plays an important role in enhancing photoelectric sensitivity.**

## I. INTRODUCTION

In the past two decades, RTS has also continuously revealed its potential in developing advanced electronic devices and circuits, such as ultrahigh-speed oscillations and enhanced functionality logic. Recently, many efforts have also been devoted to exploiting their interesting and potentially useful optoelectronic properties. By changing the laser wavelength, a photoinduced voltage shift has been observed [1-7].

## II. MODEL

A 1.2 μm GaAs layer, Si-doped to $1.6\times10^{15}cm^{-3}$ , was first grown on an n+ type (100) GaAs substrate by MBE. The undoped three-barrier, two-well structure was composed in growth sequence by a 2.5nm AlAs barrier, a 7.5nm GaAs well (central well), a 5nm thick AlAs barrier, a 25nm GaAs well (incident well), and a graded AlxGa1-xAs triangle barrier with the mole fraction of Al varying from x = 0.8 to 0.2 over a thickness of 20nm. The top contact layer was formed by a 150nm n+ Al0.2Ga0.8As layer, Si-doped to $1\times10^{18}$ $cm^{-3}$, a 50nm n+ Al0.2Ga0.8As layer, Si-doped to $4\times10^{18}$ $cm^{-3}$ , and a 30nm n+ GaAs layer, Si-doped to $4\times10^{18}$ $cm^{-3}$. A window of $200\times200$ $\mu m^2$ opened for optical access. Plotted in Figure 1 is a simplified 3D structure view of the device. The energy band diagram of the device at thermal equilibrium along the epitaxial growth direction is plotted in Figure 2.

## III. RESULTS AND DISCUSSION

Fig. 3 shows the I–V characteristics of the model at 300K under reverse bias. As the negative bias is applied across the structure, electrons are allowed to flow over the first barrier into the first well, and then electrons first cascade down to lower-lying sub-bands before they escape out of the incident well by tunneling the DBS in down-stream direction. The main peak appearing at about -3.25V is unambiguously assigned to the resonant tunneling between the ground subband ($E_1^1$) in incident wide QW and that in the central QW ($E_1$) (see Fig. 2). The weaker current peak, appearing on the

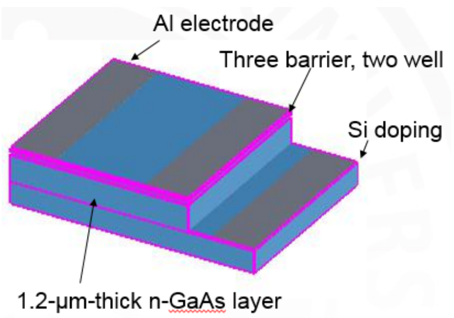


Fig. 1. The simplified 3D view of the device constructed by Lumerical software

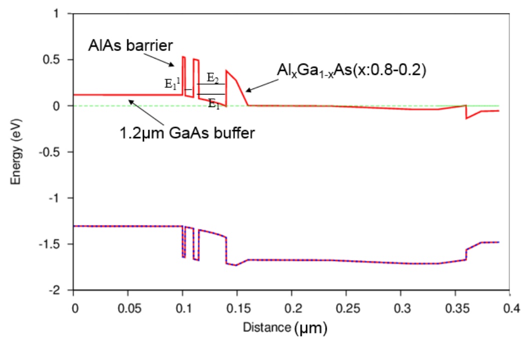


Fig. 2. The band diagram of the device under equilibrium.

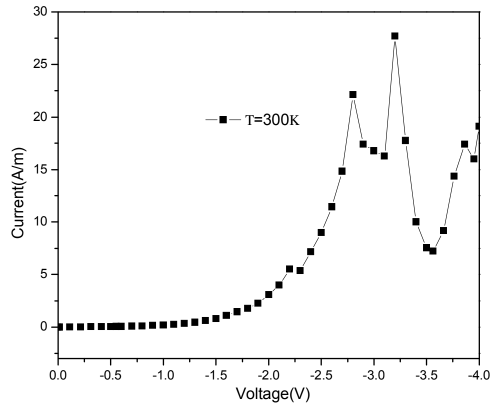


Fig. 3. The I-V characteristics for reverse bias under dark.

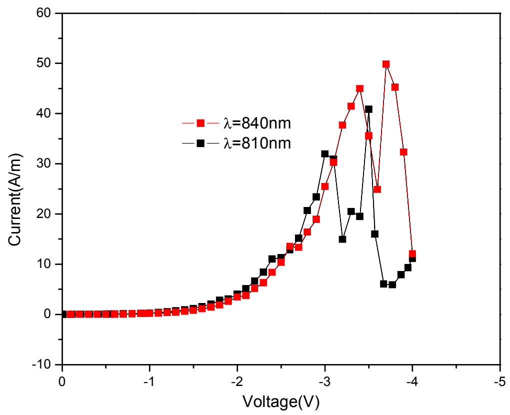


Fig. 4. The I-V characteristics for two wavelengths of 810 and 840 nm.

lower bias side, stems from the resonant tunneling between $E_2$ and $E_1^1$ subbands. The I–V curves under the laser illuminations are shown in Fig. 4. For the wavelength 810nm, the I–V curve always shows a photoinduced voltage shift towards the lower bias. Obviously, it is mainly the spatial polarizations of the photogenerated electron-hole pairs both in the incident QW and in the 1.2-μm-thick n-GaAs buffer layer that screen the electric field, and as a result, enforce a potential redistribution within the whole structure. This results in an enhanced potential drop between the incident and central QWs which makes the resonant current peaks shift to the lower bias side.

## IV. CONCLUSION

By integrating a three-barrier, two-well RTS with a 1.2-μm-thick n-GaAs layer, the photoelectric voltage shift tells us the important role played by 1.2-μm-thick n-GaAs layer (acting as the photoabsorption medium at reverse bias), which makes the polarization effect of the photogenerated electron–hole pairs in this region substantially enhanced because of its much smaller capacitance and much less bypass effect.

## ACKNOWLEDGE

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