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Investigation of the Influence of $In_{0.59}Ga_{0.41}As$ Relaxed Layer $InAs/In_{0.59}Ga_{0.41}As/GaAs$ Double Quantum Well Resonant Interband Tunneling Structure

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High peak current density and peak-to-valley current ratio (PVCR) $GaAs/In_{0.59}Ga_{0.41}As/InAs$ double quantum well resonant interband tunneling diodes (DQW RITDs) has been fabricated by the metal organic chemical vapor deposition (MOCVD) system. The PVCR value and peak current density of DQW RITD without InGaAs relaxed layer are 12 and 2.24 KA/cm^2 at room temperature, respectively. The room temperature PVCR value of 31 and a peak current density of 2.24 KA/cm^2 are obtained in DQW RITD with InGaAs relaxed layer. The InGaAs relaxed layer would partly eliminate the strained effect between GaAs and InAs layers resulting in small bending of band structure. Therefore, the relaxed layer increases the effect of energy barrier and then decreases the valley current density. The results can be evidenced by the *I-V* measurement.

KEYWORDS: InGaAs, resonant tunneling diode, quantum well

1. INTRODUCTION

Recently, double quantum well resonant interband tunneling diodes (DQW RITDs)[1-3] has been studied to improve the characteristic of low peak-to-valley current ratio (PVCR) value of resonant tunneling diode (RTD). The use of material system in RTD was usually focused on the InAlAs, InGaAs, AlGaAs, and GaAs. Based on the advantages of narrow band gap and high mobility, the authors adopted InAs/GaAs heterojunction system with InGaAs relaxed layer to raise not only PVCR value and peak current density in this report.

2. EXPERIMENTAL PROCEDURE

Firstly, the GaAs/InAs DQW RITDs were grown on an n^+ GaAs substrate by metal organic chemical vapor deposition (MOCVD) system, as shown in Fig. 1(a). The tunneling structure consisted of the following undoped layers : a InAs well of 4.1 nm-thick, a GaAs barrier layer of 4.1 nm-thick and a InAs well of 4.1 nm-thick. The top and bottom contact layers were p^+-GaAs of 2 μ m-thick and n^+-GaAs of 2 μ m-thick, respectively. The diodes were isolated, and the top and bottom non-alloyed AuZn and AuGeNi ohmic contacts were respectively formed. For the second RIT structures, as shown in Fig. 1(b), the layers thicknesses and components of each quantum well and barrier were the same as those of the first RIT structures. However, the $In_{0.59}Ga_{0.41}As$ relaxed layers were involved between every barriers and wells in the second RIT structures.

3. RESULTS and DISCUSSION

High peak current density and peak-to-valley current ratio (PVCR) GaAs/InGaAs/InAs double quantum well resonant interband tunneling diodes (DQW RITDs) were fabricated by the MOCVD method. The layer sequences of DQW RITD were schematically shown in Fig. 1. A room temperature PVCR of 12 and a peak tunnel current density of 2.24 KA/cm^2, as shown in Fig. 2(a) were obtained in RIT diodes with double quantum well of GaAs/InAs structure. A PVCR of 31 and a peak tunnel current density of 2.16 KA/cm^2, as shown in Fig. 2(b) were obtained in RIT diodes with double quantum well of GaAs/InGaAs/InAs structure.

As the InGaAs relaxed layer is involved between GaAs barrier and InAs well, the PVCR of RIT diodes is increased although the peak current density is reduced. The reason is that the quantum well depth of DQW RITD becomes deep due to reduction of strained effect as the InGaAs relaxed layer is involved. The low strained effect results in reduction of defect in the interface of heterojunction, and then decreases the leakage and thermionic current densities, and tunneling operation voltage. The leakage and thermionic current densities are the dominant factor for valley current density of *I-V* characteristic, therefore when the InGaAs relaxed layer is involved in the DQW RITDs, the valley current density of RIT diode will be decreased and then the PVCR of RIT diodes will be raised. Because the DQW RITDs with InGaAs relaxed layer possess high series resistance due to a great number of layers and large device thickness, the tunneling current density is lower than that of DQW RITDs without InGaAs relaxed layer.

4. CONCLUSIONS

In this report, we presented the excellent PVCR values with high peak current densities and the functions of InGaAs relaxed layer in the InAs/InGaAs/InGaAs DQW RITDs. Although the PVCR values are lower than the best value of our knowledge,[3] the peak current densities are better than that of the best reported data, as shown in Table I.

5. REFERENCES

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2 μm	p^+-GaAs electrode
41Å	*i*-InAs
41Å	*i*-GaAs
41Å	*i*-InAs
2 μm	n^+-GaAs buffer
n^+-GaAs substrate	

Fig. 1(a) Schematic cross section of the proposed GaAs/InAs DQW RIT structure

2 μm	p^+-GaAs electrode
41Å	*i*-InGaAs
41Å	*i*-InAs
41Å	*i*-InGaAs
41Å	*i*-GaAs
41Å	*i*-InGaAs
41Å	*i*-InAs
41Å	*i*-InGaAs
2 μm	n^+-GaAs buffer
n^+-GaAs	substrate

Fig. 1(b) Schematic cross section of the proposed GaAs/InGaAs/InAs DQW RIT structure

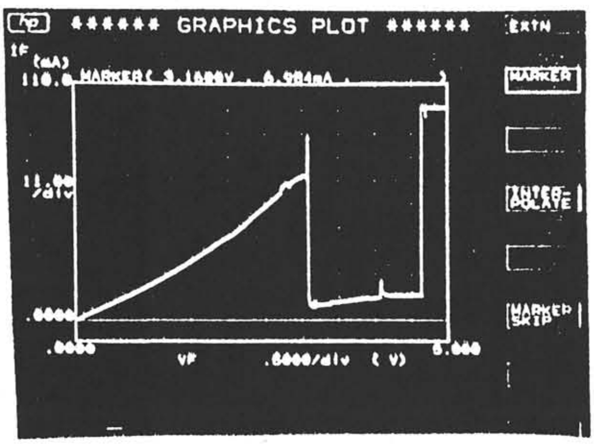

Fig. 2(a) *I-V* characteristic for the pseudomorphic GaAs/InAs DQW RITD at 300 K

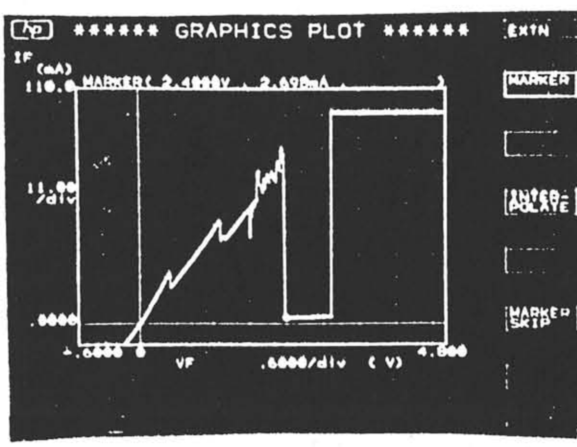

Fig. 2(b) *I-V* characteristic for the pseudomorphic GaAs/InGaAs/InAs DQW RITD at 300 K

Table I Summary of PVCR and peak current density for the best PVCR of our knowledge and our data presented here for operation at 300 K

Material systems	PVCR	Peak current density (KA/cm^2)	Reference
GaAs/InAs	12	2.24	This work
GaAs/InGaAs/InAs	31	2.16	This work
InGaAs/InAlAs	144	0.5	(3)