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Extremely High Peak-to-Valley Current Ratio Obtained in an InAlAs/InGaAs Resonant Tunneling Barrier Structure Grown by MBE

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Since the first report of an AlGaAs/GaAs resonant-tunneling barrier (RTB) structure by Tsu and Esaki in 1973 [1], much effort has been made to improve the negative differential resistance (NDR) characteristics of AlGaAs/GaAs RTB structures by changing structure parameters (quantum well width, barrier layer thickness, barrier height, and spacer layer thickness) [2-6] for improving characteristics of new RTB devices, such as a resonant-tunneling hot electron transistor (RHET) which has been first developed in 1985 [7]. Nevertheless, NDR characteristics of an AlGaAs/GaAs RTB structure are still unsatisfactory.

In this study, we tried to change another parameter, the electron effective mass of RTB, to realize a high-quality RTB structure. An InAlAs/InGaAs RTB structure, lattice-matched to InP, was grown for the first time by MBE, and excellent NDR characteristics were obtained.

Fig. 1 shows the schematic cross-section of an InAlAs(41 Å) /InGaAs(61.5 Å)/InAlAs(41 Å) RTB diode (ohmic contact of about 50 μm in diameter) and its energy band diagram. The RTB structure, sandwiched between thick n-InGaAs layers (Si doped, $n=1\times10^{18}cm^{-3}$), was grown on an InP substrate at a growth temperature of 470°C by MBE. Undoped InGaAs spacer layers (15 Å) were introduced on both sides of the barrier structure.

Typical I-V characteristics (77K) of the RTB are shown in Fig. 2. A very large peak-to-valley current ratio (Jp/Jv) of 11.7 was attained at a peak current density as high as 2.2×10^{4} A/cm^2, which is the highest value ever reported for any RTBs.

In Fig. 3, the Jp/Jv ratios at 77K are plotted as a function of Jp for the InAlAs/InGaAs RTB, together with data of AlGaAs/GaAs RTBs [3-6]. It can be seen that the Jp/Jv ratio decreases with increasing Jp. For AlGaAs/GaAs RTBs, the highest Jp/Jv ratio of more than 10 was obtained for $Jp < 3\times10^{3}$ A/cm^2. On the other hand, the InAlAs/InGaAs RTB showed the much improved NDR characteristics, that is, the large Jp/Jv ratio (11.7) with the very high Jp value(2.2×10^{4} A/cm^2). This Jp value is almost one order of magnitude higher than that of AlGaAs/GaAs RTBs for

the same Jp/Jv (about 10). This excellent characteristic of the InAlAs/InGaAs RTB is dominantly due to the smaller effective mass in the InAlAs barrier layer compared with the AlGaAs barrier.

References

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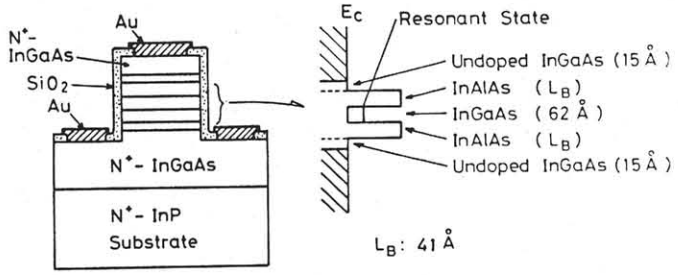

Fig. 1.

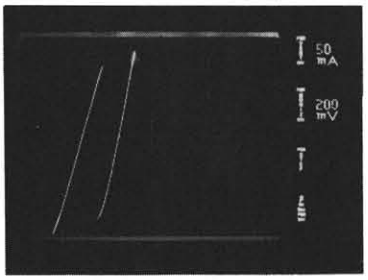

Fig. 2.

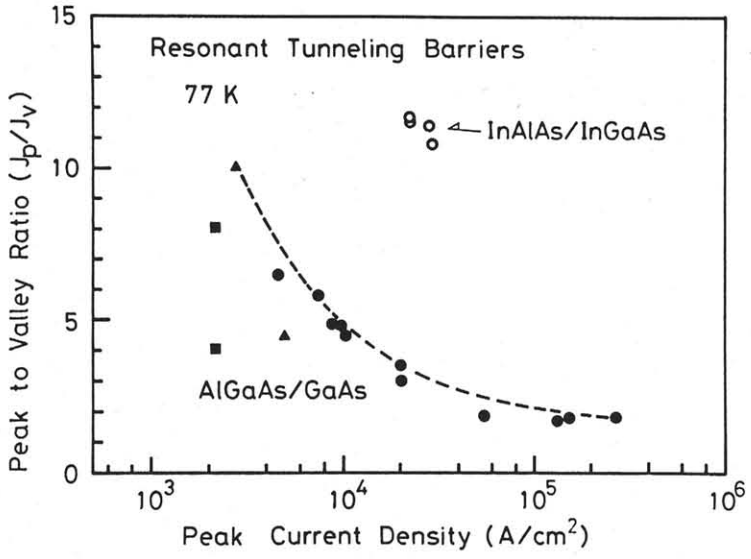

Fig. 3.