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Demonstration of a DQW Resonant Interband Tunneling Diode with a 300K Peak-to-Valley Ratio over 100

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Since the first publication in 1989 [1] on the concept of resonant interband tunneling (RIT), there has been a large number of papers reporting on experimental demonstration and theoretical investigation of the three different versions of the RIT devices proposed by Sweeny and Xu [2]. The results presented in these papers confirm that resonance effects are greatly enhanced with the combination of interband coupling of quantum levels and bandgap blocking. They also show that the concept of RIT is applicable to polytype heterostructures, homojunction delta-doped structures and pn-junction heterostructure.

In this work, we report, for the first time, experimentally measured current-voltage characteristics with a peak-to-valley current (P/V) ratio of 104:1 at 300K in a double-quantum-well RIT diode implemented in InP system. This represents the highest room-temperature P/V ratio ever reported in any resonant tunneling diodes.

The devices were grown by MBE on InP, as shown in Figure 1. The layer structure consists of two $In_{0.52}Al_{0.48}As$ carrier supply (or contact) layers, with appropriate *n* and *p* doping of 3×10^{19} cm^{-3}, each adjacent to 40 Å $In_{0.53}Ga_{0.47}As$ undoped quantum wells that were in turn separated by a central 20 Å undoped InAlAs barrier layer. As can be seen in Fig.2, the bottom of the conduction band QW on the left-hand side of the pn junction is coupled, through interband tunneling, to the top of the valence band QW on the right-hand side. This particular band alignment forms the basis of the resonant interband tunneling processes critical to the operation of this device; and is a special case of a new class of quantum well systems called "leaky quantum wells" [3].

The resonances of interband tunneling occur when a quasi-Fermi level aligns with a quantum level in either the conduction-band QW or the valence-band QW or both. This is illustrated in Figure 2, which shows the propagation and the transmission of the electron wave component and the hole wave component calculated by Green's function approach at a resonant energy.

The device structures were mesa etched into these layers around alloyed contacts. The design of the layer structure and doping profile was guided by a self-consistent numerical model that takes into account the space charge, electron and hole distributions and the electron and hole waves coupled in the $\mathbf{k}\cdot\mathbf{p}$ scheme.

Figure 3a is the measured characteristics of a 100-µm-diameter diode at 300K which exhibits a peak current of 15.6 mA and a valley current of 0.15 mA, giving rise to a P/V ratio of ~104:1. Moreover, the measured I-V curve clearly displays a second current peak indicating the occurrence of a second resonance which was predicted in [1] for QWs with multiple levels.

Figure 3b shows the I-V characteristics measured in a second device structure which is the same everywhere as the first one except that the central barrier is 40 Å thick instead of 20 Å. A P/V ratio near 70:1 is obtained at 300K. These results agree very well with that of the theoretical model.

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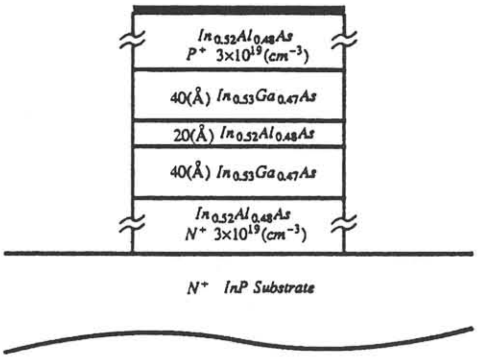

Fig.1 Illustration of the device cross section and layer parameters.

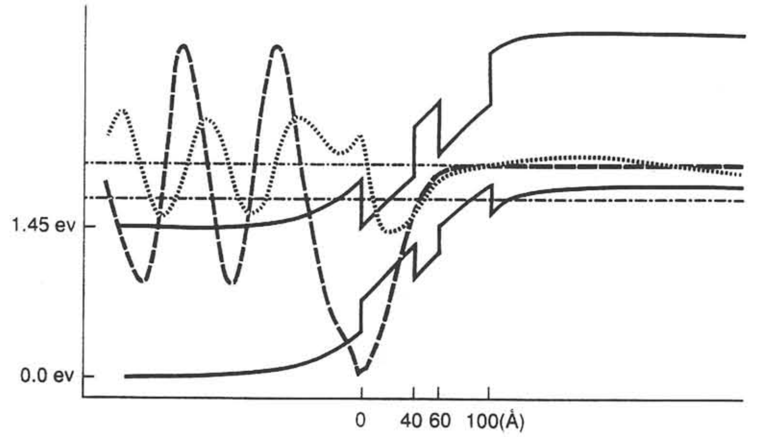

Fig.2 Calculated zero-bias band structure and the electron wave component (dashed) and the hole wave component (dotted) calculated by Green's function method.

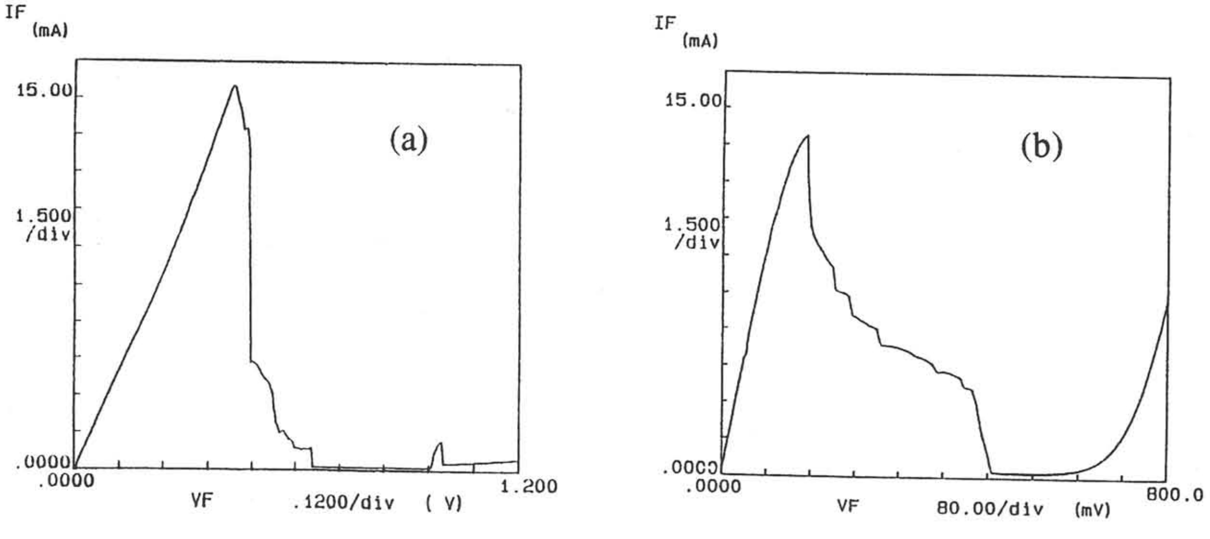

Fig.3 I-V characteristics of a 100-μm-diameter *pn* junction RIT diodes measured at room temperature. (a) for a 20Å central barrier and two 40Å wells with a peak-to-valley current ratio 104:1, and (b) for a 40Å central barrier and two 40Å wells with a peak-to-valley current ratio 68:1.