Extended Abstracts of the 1995 International Conference on Solid State Devices and Materials, Osaka, 1995, pp. 1053-1054

Observation of the Electron Reflection from N^-/N^+ Junction in GaAs by Resonant Tunneling through Pseudoquantum Well in Single Barrier Heterostructure.

Yu. V. Dubrovskii[1] , T.G. Andersson*, Yu. N. Khanin, I. A. Larkin, E. E. Vdovin.
Institute of Microelectronics Technology. Russian Academy of Sciences. Chernogolovka. Moscow District. 142432. Russia. E-mail:<yuvdu@iptm3.sherna.msk.su>
Tel: +7-095-521-51-83. Fax: +7-096-515-35-88
*Department of Physics. Chalmers University of Technology. S-412 96 Göteborg. Sweden.

Traditionally quantum electron reflection from a smooth potential drop at the N^-/N^+ junction is not taken into account in semiconductor device simulation. We made direct measurements of the electron reflection coefficient from N^-/N^+ junction in GaAs and demonstrated that it's value is a few percent. This can be essential for device operation.

Weak aperiodic oscillations in current-voltage tunneling characteristics of a single barrier heterostructure with a 60 nm low doped GaAs spacer layer and a 3.5 nm AlAs barrier have been found at 4.2 K (Fig. 1, lower curve). These are explained as the manifestation of resonant tunneling through virtual states in a wide quantum pseudo well coinciding with a spacer layer region restricted by the real barrier on one side and by the N^-/N^+ junction on the other (see the insert in Fig. 2).

With a magnetic field transverse to the current, the oscillation amplitude is suppressed and the peak positions slightly shift to higher voltages. At a field higher than 4T, a new set of oscillations appears at low biases, which is related to the tunneling into the skipping orbit states at the barrier interface.

We have compared our results with the resonant tunneling experiment through the states in a wide quantum well (double barrier structure) reported by Alves et al [1]. The width of the well was 60 nm, equal to the spacer layer length in our samples. The average distance between the oscillations and their behavior in the magnetic field in our experiments are the same as in the wide quantum wells were reported in the previous works [1,2], and the oscillation amplitude is more than two orders of magnitude less.

It follows from the simple theory of resonant tunneling [3] that $(\Delta I/I) \sim R$, where ΔI - additional current in resonance, I - current out of resonance, R - reflection coefficient from the N^-/N^+ junction. The experimental data and the theoretical value obtained for an abrupt potential drop agree fairly well, if we take into account that for a smooth potential drop there should be an additional term proportional to $\exp(-\lambda/W)$, where λ - electron wave length and W - potential change length (Fig. 2). Reflection coefficient does not depend on the temperature.

To our knowledge, this is the first observation of the electron quantum reflection from a smooth potential drop at the N^-/N^+ junction.

1. E. S. Alves, M. L. Leadbeater, L. Eaves et al. Sol. State Electr. **32**, 1627 (1989).
2. M. Helm, F .M. Peeters, P. England, J. R. Hayes, E. Colas. Phys. Rev. **B39**, 3427 (1989).
3. B. Ricco and M. Ya. Azbel. Phys. Rev. **B29**, 1970 (1984).

---

[1] Author for contacts.

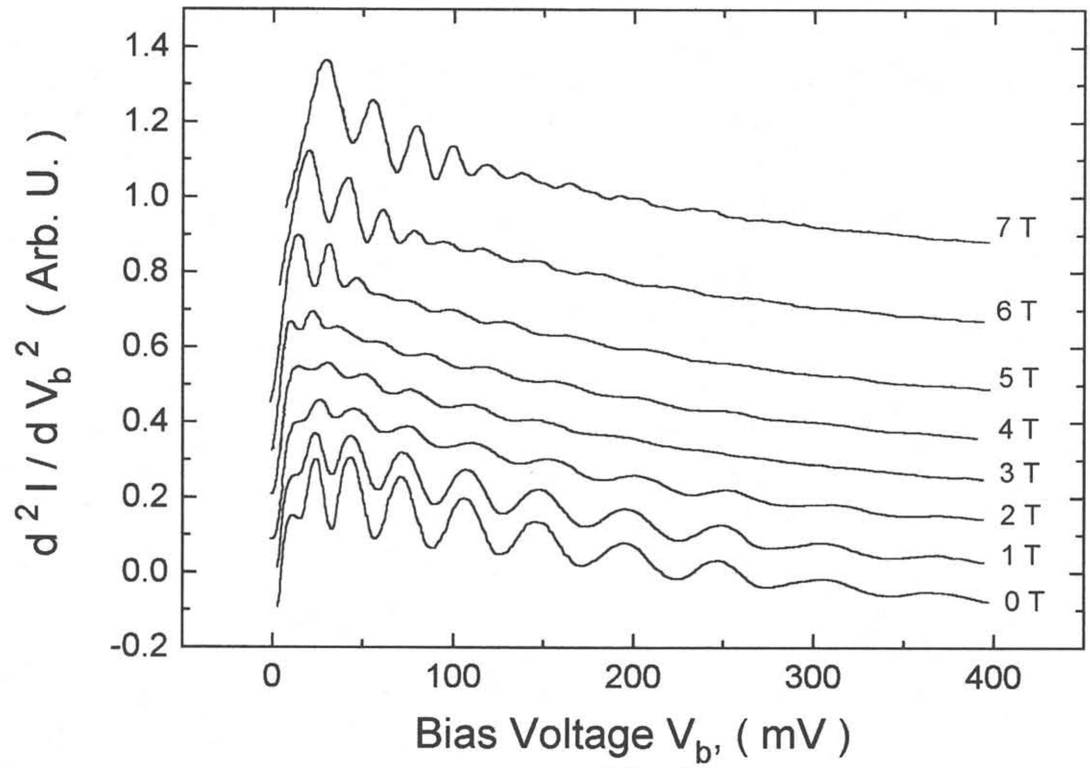
d^2 I / d V_b^2 (Arb. U.)
Bias Voltage V_b, (mV)
7 T
6 T
5 T
4 T
3 T
2 T
1 T
0 T
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
0
100
200
300
400

Fig.1

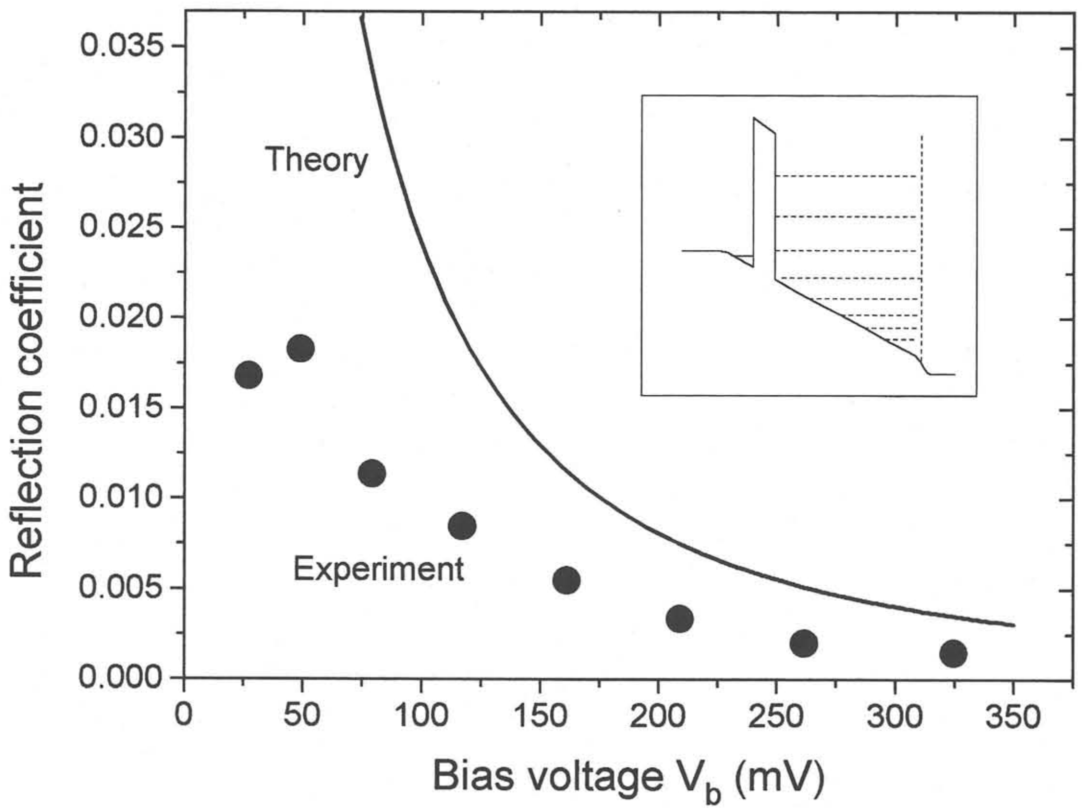
Reflection coefficient
Bias voltage V_b (mV)
Theory
Experiment
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
50
100
150
200
250
300
350

Fig.2