NOVEL HETEROSTRUCTURE DEVICE FOR THZ POWER GENERATION

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It has been shown that oscillations at THz frequencies can occur when carriers in a semiconductor device have a particular energy-wave vector dispersion relation with a section of a negative effective mass (NEM) like in Fig. 1. The device structures that have been investigated so far had one major disadvantage: These oscillations occur only at cryogenic temperatures and the generated RF output power is low [1]. The main reason for this is the range of energies where the NEM is present in the dipsersion relation. To overcome this disadvantage and to place this region within a more desirable interval (0.1–0.3 eV), a new heterostructure device is proposed. The main idea is the use of a structure that consists of two parallel channels of current conduction with different properties. In one of them, *i.e.*, the quantum well (QW) of Fig. 2, electrons, as the carrier chosen here, have a small effective mass, whereas in the other channel, *i.e.*, the superlattice (SL), the effective mass of electrons is several times higher. At $k_z = 0$ (where k_z is the component of the wave vector **k** along the growth direction of the SL), the electron wave function is localized almost completely in the QW. As k_z increases, the electron wave function expands further into the SL. As a result, electrons become heavier and heavier. Such a dynamic (quantum) real-space transfer (without any electron scattering) causes an NEM section to appear in the lowest subband of the QW. The position of this section relative to the conduction band edge, the width in energy of this subband, and its distance from upper subbands is determined by key parameters of the QW and SL. Several versions of such structures were investigated. The most promising choice is a configuration where the transverse motion of electrons in the SL is limited by an additional electric field. This electric field results from a *p*-type doping in the SL barrier layers and the *n*-type delta doping of the barrier layer on top of the QW. This electric field provides additional control over where the NEM section occurs in the dispersion relation. The QW and the top barrier layer with delta doping can be realized on the edge of the SL using the same method of cleaved-edge overgrowth in an MBE system as for T-shaped quantum wires. An alternative method is glancing-angle overgrowth in an MBE system. Numerical calculations were carried out for the proposed device structures and they yielded the best results for a fully strain-compensated SL of lattice-mismatched InGaAs/InAlAs on InP and a QW of InGaAs lattice-matched to InP.

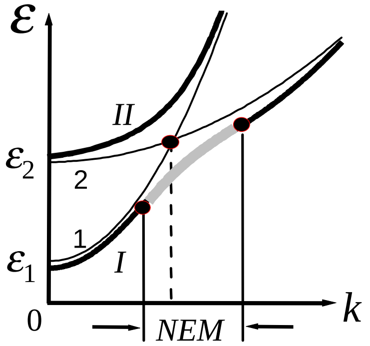

Fig. 1. The formation of an NEM region in the lowest branch *I* from the anti-crossing of the two initial dispersion branches 1 and 2.

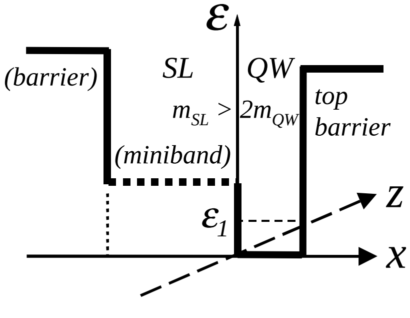

Fig. 2. Simplified heteropotential profile for one of the proposed device structures as used in the calculations.

[1] Z. S. Gribnikov, N. Z. Vagidov, A. N. Korshak, and V. V. Mitin, J. Appl. Phys. 87, 7466 (2000).