*QUANTUM-MECHANICAL SEMICONDUCTOR GENERATORS AND AMPLIFIERS OF ELECTROMAGNETIC OSCILLATIONS**

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IN the present note we consider the possibility of using the electronic transitions between the conduction band (valence band) and the donor (acceptor) impurity levels of a semiconductor to obtain electromagnetic radiation assisted by the phenomenon of stimulated emission in a fashion similar to that which takes place in the molecular generator.[1]

To make semiconductor generators and amplifiers, one needs to obtain such a distribution of electrons (holes) in the conduction (valence) band as would exist if the effective temperature of the conduction electrons (holes) relative to the ionized donors (acceptors) were negative. Such a semiconductor has negative losses at the frequency corresponding to transitions of electrons (holes) from the conduction (valence) band to the impurity level. Therefore, on irradiating a semiconductor in the condition described above with an electromagnetic wave, it is possible to obtain amplification of this wave due to the quanta of stimulated emission. Further, on fulfilling certain conditions (the conditions of self-excitation), such a device can function as a generator.

To obtain negative temperatures it is proposed to use the impurity ionization mechanism which operates in a semiconductor specimen at a low temperature when an electric field pulse is applied.

The peak voltage of the pulse is chosen so that impact ionization of the impurity atoms or direct field-extraction results. Thus, the number of electrons (holes) in the conduction (valence) band increases sharply, so that practically all the impurity atoms are ionized. Provided the decay of the voltage pulse is sufficiently rapid, all the electrons (holes) fall to the lowest energy levels of the corresponding band. The electron (hole) density and the crystal temperature should be chosen so that in the conduction (valence) band a state is thus created which is almost degenerate and which is equivalent to a negative temperature relative to the donor (acceptor) levels.

The state of negative temperature will be preserved for the relaxation time of the electrons (holes) with the vacant impurity levels. For impurity contents sufficiently small compared with the number of atoms in the crystalline lattice, the lifetime τ_2 of conduction electrons (holes) will be much larger than the time τ_1 between collisions of the electrons (holes) with the lattice. The time τ_2 can be controlled by the impurity concentration. During the interval τ_2 the system may be used as a generator or amplifier of electromagnetic oscillations. The oscillation frequency is determined by the position of the impurity energy levels relative to the bands. The original spectral line breadth is determined by the energy spread of the occupied levels in the main bands.

For the system to work as a generator it is necessary to satisfy the conditions of self-excitation, which involve the choice of the transmission and reflection coefficients of the waves at the specimen boundary.[2,3] Reducing the surface reflection coefficients or the dimensions of the specimen can change the system from a generator into an amplifier.

Every pulse of the external voltage will be accompanied by the formation of a state of negative temperature; thus such a system will function in a pulsed manner.

The operating principle in quantum-mechanical semiconductor generators and amplifiers using electronic transitions between two different bands will not differ from that discussed above, since in this case also two characteristic times, τ_1 and τ_2, exist.

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[2] N. G. Basov, Радиотехника и электроника (Radio Engineering and Electronics) **3**, 297 (1958).

[3] A. M. Prokhorov, J. Exptl. Theoret. Phys. (U.S.S.R.) **34**, 1658 (1958), Soviet Phys. JETP **7**, 1140 (1958).

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118