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THE IMPACT OF THE SECOND MODE ON EFFICIENCY OF ENERGY CONVERSION IN A GUNN DIODE WITH INTRICATE CATHODE

V. I. Kanevskii, Ik-Wan-Che, and V. Ye. Chaika

Kiev Polytechnic Institute, Ukraine

The paper is devoted to qualitative investigation of the influence of the second mode of oscillation on the energy conversion efficiency in *n*-GaAs Gunn diodes with a complex cathode. The presence of the second mode of the field is shown to increase the diode efficiency by 10–20%. A new structure of Gunn diode is suggested, which involves special cathode quasi-island ohmic contacts and a built-in triangular barrier in the diode active region.

One of the ways to improve the energy conversion efficiency in n^+-n-n^+-Ga-As Gunn diodes at the fundamental oscillation mode is the use of the external signal's second mode. As has been shown in [1], in the biharmonic conditions, at a certain proportion between amplitudes and phases of both harmonics, we can enhance the Gunn diode efficiency at the fundamental mode while having a negative conductance at the second mode. The use of hot electrons in single-mode conditions in Gunn diodes with Schottky barrier, or injectors of hot electrons [2], or cathodes of an intricate shape [3, 4], etc., improves the energy conversion efficiency in the biharmonic conditions. Further increase in efficiency is attained in the event of selection of electrons injected into the active region of Gunn diodes with a complex cathode [5].

The work is devoted to the impact of the second mode of an external signal on the efficiency $\eta(\varepsilon_{in}, \varphi_{SH})$ of energy conversion in the Gunn diode with complex cathode at the fundamental oscillation mode. We use the single-part model of carrier transport in a short n-GaAs bar, the Monte-Carlo method, and some simplifying assumptions described in [5]. The choice of the electric field in the diode corresponds to its equivalence to a parallel resonant circuit [6].

Similar to the Gunn diode described in [1], the increase in efficiency and expansion of the frequency range in a short n-GaAs bar at the fundamental mode in biharmonic conditions can be realized in the event of negative conductance at the second mode. Otherwise there arises a need to obtain the energy at this mode from outside. The relation for estimating the efficiency at the second mode can be derived if in expression (5) given in [5] for efficiency $\eta(\omega)$ we replace $\sin(\omega t)\mathrm{d}t \cdot E_1$ by $\cos(2\omega t)\mathrm{d}t \cdot E_2$ assuming that the phase shift between the first and second field modes, $\varphi = \pi/2$. The dependence of energy conversion efficiency $\eta(\varepsilon_{in}, \varphi_{SH})$ in short bars at the first and second field modes on the delay angle φ_{SH} can be obtained if in formulas (1) and (2) in [5] we replace ωt by $(\omega t + \varphi_{SH})$.

Figure 1 illustrates the dependencies of energy conversion efficiency in n-GaAs material and in a short bar at the fundamental oscillation mode on the frequency of the electric field described by relation (1) in [5]. Curves *1* and *2* in Fig. 1 represent the behavior of the efficiency in n-GaAs material, where curve *1* corresponds to the external field harmonic signal while curve *2* — to the biharmonic signal. The parameters that have been used for calculating these curves are produced from a computational experiment. As a result, efficiency of the material under biharmonic conditions has increased by 8–12%. The presence of the second harmonic makes it possible to retain the electric field in the material close to the threshold value for a longer time than in the absence of this harmonic. So the concentration of electrons in the central valley comes to the steady state more rapidly.

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