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# 400 GHz electromagnetic radiation sources based on IMPATT diodes

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**Abstract.** The results of research on the creation and development of microwave radiation sources in the long-wave part of the terahertz range (100-400 GHz) using double-drift impact avalanche and transit-time diodes (IMPATT diodes) are presented. Minimum contour losses and maximum output power of low impedance IMPATT diodes are achieved in the oscillatory system on the open radial transmission feeder. Equivalent circuits of generators are considered, and electrophysical parameters of IMPATT structures are given. Schemes of designs of microwave radiation sources and their main parameters are given.

## 1 Introduction

In the millimeter and submillimeter wavelength ranges, the level of microwave power of continuous and pulsed IMPATT diodes is one of the most important parameters. To reduce losses, the oscillating system for diodes should be performed on an open radial transmission feeder. In this case, a fairly high impedance of the transmission line is transformed into a relatively low load impedance of the radial line. Total losses in impedance transformers should be minimal.

## 2 Design and equivalent circuit of the microwave radiation source

In the known designs of millimeter-wave radiation sources, the inclusion of a diode using a waveguide-coaxial bond is widely used. Figure 1 shows an equivalent circuit of the generator with a radial resonator, it does not take into account a number of factors and features of the field at the diode switching point, but with the accuracy necessary for practice, it allows to perform engineering calculations of microwave power sources on avalanche-span diodes.

A radical way to solve the problem of building generators on IMPATT diodes with high energy characteristics is to create a design of packaged diodes that preserves the principle of resonant transformation of the diode impedance. Realization of this task consists in the creation of high-frequency circuits providing coordination of traffic and diode impedances in a wide range of operating frequencies.

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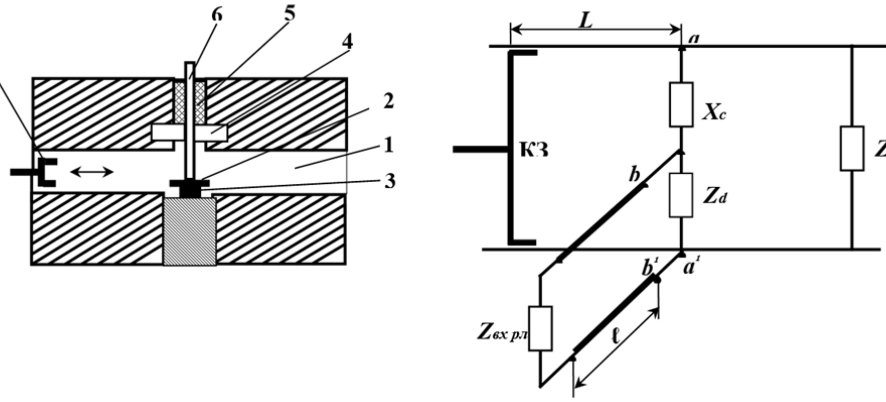


**Fig. 1.** IMPATT diode generator with radial resonator design scheme and equivalent circuit.

## 3 Electrical properties of avalanche transit-time structures

In order to increase the level of output microwave power of radiation sources in the short-wave part of the millimeter wavelength range, it is more advantageous to use double-drift impact avalanche and transit-time structures.

The multiplication layer does not go very deep into the p–region. As a result, the full width of the multiplication layer increases slightly. In this case, the capacitance decreases, which leads to an increase in the diode impedance per unit area and a reduction in its negative figure of merit. As a result, along with an increase in output power, a wider operating frequency band is achieved [1].

## 4 Radio pulse frequency converters of high multiplicity

The problem of creating highly stable sources in the terahertz range can be solved by using IMPATT diode structures in low-frequency signal frequency conversion devices. It is known that in the mode of such conversion the level of microwave power of the output signal on the $N^{th}$ harmonic $P_{out} \sim 1/N$.

The studies show that the high efficiency of frequency multiplication on IMPATT diodes is determined mainly by the amplification mechanism within the duration of the current pulse through the diode and the phase synchronization of these microwave oscillations by harmonics of the periodic sequence of current pulses. This mechanism of effective frequency multiplication can be applied to various microwave devices [2].

## 5 Conclusion

The main features of design solutions of semiconductor radiation sources on IMPATT diodes in the long-wave part of the terahertz range are considered. In order to increase the output microwave power in the continuous generation mode, it is advisable to double-drift impact avalanche and transit-time diodes with a small multiplication layer value. To match the IMPATT diode impedance with the transmission line impedance, ruby clock bushings are used, which are considered as a radial line with distributed parameters. In the frequency range of 120-170 GHz in continuous generators, made on the basis of waveguide-coaxial bond (channel cross-section 0.8 x 1.6 mm), the power of 20-50 mW was obtained. To create power sources in the frequency range of 200-400 GHz, efficient frequency converters of a highly stable low-frequency signal are proposed and implemented. The power level of the output signal on the $N^{th}$ harmonic significantly exceeds the power level of the frequency multiplier. In the proposed designs of frequency converters the power level of coherent radiation is achieved 5-10 mW in the frequency range 250-320 GHz.

Further process in the field of increasing the power of radiation in the terahertz range should be expected with the improvement of the technology of manufacturing diodes based on wide-band semiconductors, such as gallium nitride.

## References

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