Project of CW High Harmonics Double-Beam Gyrotrons with Operating Frequencies in the Range 0.7-1.0 THz

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***Abstract*— The concept of a CW THz range gyrotrons operated at the second or third cyclotron harmonic is presented. To suppress the mode competition effects a double beams scheme is applied. The helical electron beams are formed in a double-beam triode magnetron-injection gun (MIG), where both emitters of the electron beams are located on a common cathode of the conventional MIG. Results of numerical simulation of electron beams formation and mode excitation have been presented. The concept makes possible high power (several hundred Watts) single-mode gyrotron operation at 0.7-1.0 THz frequency range at high harmonics.**

I. Introduction

The CW terahertz radiation sources are now increasingly used in various fields of science and technology. Even a very short list of the most important and partly implemented applications includes biology, chemistry, spectroscopy of organic molecules, medicine, plasma diagnostics, security monitoring systems, high-resolution photolithography, etc. In comparison with other exciting THz sources, gyrotrons are much more compact than free-electron lasers and have a several orders higher power than backward wave oscillators.

As it is well known, gyrotrons require strong magnetic fields for providing of the cyclotron resonance conditions. For modern cryomagnets with reasonable size and cost magnetic field intensity is about 15-20 T, so for 0.7-1.0 THz frequency range operation at cyclotron harmonics is needed. For suppression of parasitic modes methods of electron selection (for example, axis-encircling electron beam) or electrodynamics (step cavity, etc) are usually used. Unfortunately, such methods are based on complicated electron optical systems or need extremely high accuracy of manufacturing. So, a possible solution is to use multi-beam scheme. Experience in the development of such systems [1] shows that even the use of one additional beam with a current of about 20-30% of the main-beam current can effectively suppress the spurious modes and increase the gyrotron power at the second harmonic by about two times. In the paper this method were applied to development of concept of a CW THz range gyrotrons operated at the second or third cyclotron harmonic.

II. Gyrotron Design and Results of Simulations

The optimized configuration of MIG electrodes, obtained by EPOS code for second harmonic $TE_{8,5}$ mode is shown in Figure 1. For numerical analysis of mode excitation and mode competition we use homemade codes and 3D CST Studio software. The results of simulations are presented in Figure 2. It is seen, that for beam current about 2A, at single beam scheme excitation of fundamental parasitic mode has been observed (left column). At the same time for double beams system with the same parameters stable single mode operation at second harmonic take place (right column).

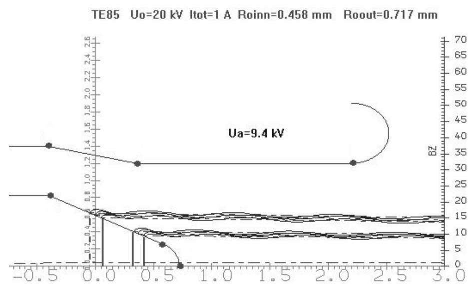

Fig. 1. Profile of magnetron injection gun (cathode and anode).

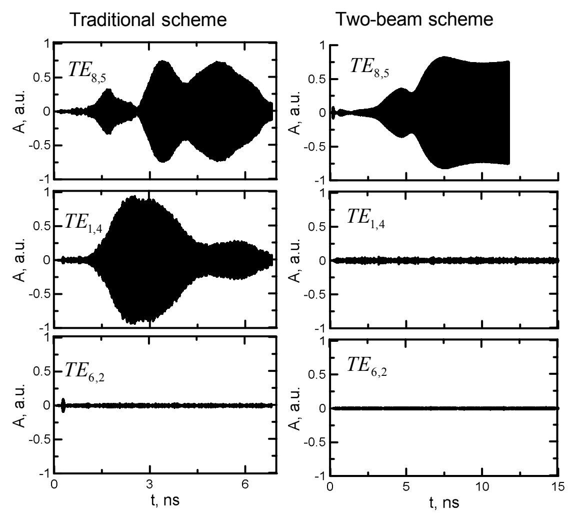

Fig. 2. Start-up scenario of single beam and double beam gyrotron.

III. Summary

The double beams scheme of gyrotron has been proposed for high power (several hundred Watts) high harmonic single-mode operation at 0.7-1.0 THz frequency range. The optimization of electron optical system was made and MIG is under development. Results of numerical modeling confirmed significant improvement of operating mode stability, as well same as an increasing of maximum output power and width of operation zone.

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References

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