HIGH-CURRENT THZ-BAND GYROTRONS BASED ON AXIAL-SLIT CAVITIES*

YU. YU. DANILOV, A. N. LEONTYEV, A. M. MALKIN, R. M. ROZENTAL, D. YU. SHCHEGOLKOV
Institute of Applied Physics RAS, Nizhny Novgorod, Russia

At present, the prospects of generation high-power terahertz-band radiation are under intense investigation. For instance, in [1], a 330 GHz surface-wave oscillator was studied with output power exceeding 40 MW fed by an electron beam with an energy of 380 keV and a current of 2.2 кA. In [2], prospects for realization of 2 THz planar free electron lasers with a multi-MW power were discussed. Currently, gyrotrons are known to be the highest-power CW radiation sources in THz band, as they feature high mode selectivity allowing for use the highly oversized electrodynamical systems [3]. Gyrotrons fed by high-current relativistic beams can potentially be used as sources of high-power THz radiation. However, the selective excitation of the operating oscillation can constitute a significant problem in this case.

Here we propose a new type of high-selectivity resonators for high-current gyrotrons based on the coupling of modes with proportional azimuthal indexes and close eigenvalues. Based on the analytic approach and numerical simulations, we demonstrate that in an oversized cylindrical cavity with M axial slits, the coupling of the modes of regular waveguide with azimuthal indexes M and $2M$ can lead to formation of high-Q modes with small radial losses at the quasi-cutoff frequencies.

Simulations of electrodynamical properties of axial-slit cavities were conducted using the CST Microwave Studio software. As an example, Fig. 1a shows the cross section of a six slits cavity. The "internal" part of the eigenmode has six variation along the azimuth while the external has twelve (Fig.1b). Similar transverse structure can be obtained by arithmetic summation of the $TE_{6,4}$ and $TE_{12,2}$ mode fields (Fig.1c). Clearly, the "supermode" is based on the combination of the specified modes of the cylindrical waveguide coupled via axial slits.

We consider the cavities for $TE_{6,4}$+$TE_{12,2}$ mode combination in 300 GHz band and и $TE_{8,7}$+$TE_{16,4}$ mode combination in 500 GHz band. Using 3D PIC simulations at KARAT code [4], we show the possibility of development of gyrotrons with output power of up to 100 MW based on these cavities. We have also simulated the electron optics systems of high-current THz-band gyrotrons with an initially rectilinear electron beam pumped by a kicker and subsequent compression in rising magnetic field.

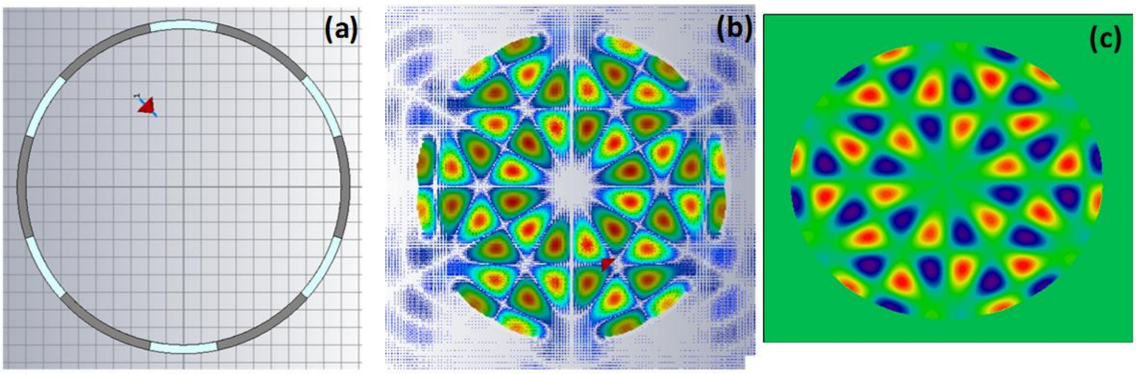

Fig.1. Cross section of a six slits cavity (a), transverse structure of the axial component of the microwave magnetic field in the case of "supermode" excitation (b), arithmetic sum of $TE_{6,4}$ and $TE_{12,2}$ transverse structures (c).

REFERENCES

[1] S. Li, J. Wang, D. Wang, "Relativistic Surface Wave Oscillator in Y-Band with Large Oversized Structures Modulated by Dual Reflectors," *Sci. Rep.* vol. 10, art.no. 336, January 2020, doi: 10.1038/s41598-019-55525-9

[2] A.V. Arzhannikov, N.S. Ginzburg, G.G. Denisov, P.V. Kalinin, N.Y. Peskov, A.S. Sergeev, S.L. Sinitskii, "A traveling-wave ring resonator with Bragg deflectors in a two-stage terahertz free-electron laser," *Tech Phys. Lett*, vol. 40, no.9, pp. 730-734, September 2014, doi: 10.1134/S1063785014090028

[3] M.Yu. Glyavin, G.G. Denisov, V.E. Zapevalov, M.A. Koshelev, M.Yu. Tretyakov, A.I. Tsvetkov, "High-power terahertz sources for spectroscopy and material diagnostics," *Physics-Uspekhi*, vol. 59, no. 6, pp. 595-604, doi: 10.3367/UFNe.2016.02.037801

[4] V.P. Tarakanov, "Code KARAT in simulations of power microwave sources including Cherenkov plasma devices, vircators, orotron, E-field sensor, calorimeter etc.," *Proc. EPJ Web Conf.*, 2017, vol. 149, art.no. 04024, doi: 10.1051/epjconf/20171490

* This work was supported by the Institute of Applied Physics of the Russian Academy of Sciences (IAP RAS) Project through the Program “Development of engineering, technology and scientific research in the field of atomic energy until 2024” under Grant 0030-2021-0027.