GENERATION OF THZ RADIATION BY SEQUENCE OF RING BEAMS IN MULTILAYER DIELECTRIC WAVEGUIDE

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ГЕНЕРАЦИЯ ТЕРАГЕРЦОВОГО ИЗЛУЧЕНИЯ ПОСЛЕДОВАТЕЛЬНОСТЬЮ КОЛЬЦЕВЫХ СГУСТКОВ В МНОГОСЛОЙНОМ ДИЭЛЕКТРИЧЕСКОМ ВОЛНОВОДЕ

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Аннотация. *В данной работе описывается новый тип источника ТГц излучения в многослойном диэлектрическом волноводе, основанного на эффекте Вавилова-Черенкова и создаваемого последовательностью электронных кольцевых сгустков. В программе Mathcad было проведено моделирование данной задачи. Расчет осуществлялся при определенных параметрах сгустков и волновода, при которых осуществляется возбуждение ТМ03 моды для формирования терагерцового излучения на частоте 531.2 ГГц. Кроме того, определена степень монохроматичности сформировавшегося излучения, приведены графики спектра, а также проанализированы полученные результаты.*

Introduction. Recently there have been tendencies related to tendencies related to the development of Terahertz radiation sources, as well as its wide application in various fields of science, such as chemistry, biology, medicine. The main requirements for terahertz radiation are the frequency, amplitude, and the degree of monochromaticc of radiation. The main purpose of the work is to select the parameters of the waveguide and ring-shaped bunches propagating in the dielectric waveguide and generating THz radiation based on TM03 mode which has a high degree of monochromaticity. We used ring beams for creating THz radiation because transverse instability of these bunches is less than usual gaussian bunch [1].

Method of investigation. In this work we use macroparticle method [2,3] to simulate the generation of THz radiation. The macroparticle method is based on presentation of bunch with charge Q as number of N particles with charges Q/N. Each particle has a mass which is equal to the mass of the electron. The field created by the bunch is calculated as the sum of the fields of all the macroparticles.

Formulation of the problem. The sequence of circular electron bunches propagates in a multilayer dielectric cylindrical waveguide, which is a dielectric-vacuum-dielectric-metal structure (Fig. 1). The circular bunch excites the Vavilov-Cherenkov radiation in the dielectric waveguide behind itself. With a certain selection of the parameters of the waveguide (a,b,c) and the distance between the bunches, the TM0n-type modes are excited. Empirically selecting the distance between bunches, we can excite a certain mode, corresponding to the frequency of radiation of the terahertz range. The instability arising from the dynamics of ring bunches is due to the presence of hybrid HEM type modes. In Table 1, we define the parameters of the waveguide and bunches for numerical simulation.

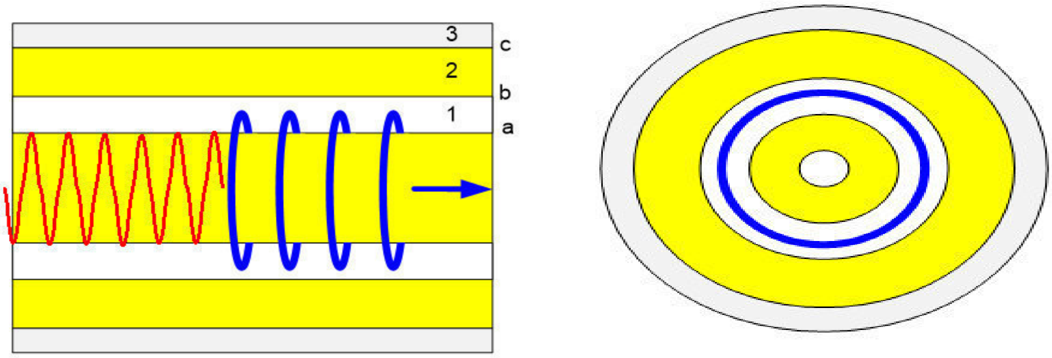

Fig. 1 - Longitudinal (left) and transverse (right) views of a cylindrical waveguide.
(1) - vacuum channel, (2) - dielectric layer,
(3) - metal walls. The blue arrow shows the direction of the clot

Table 1

Waveguide and bunch parameters for numerical simulation

Parameter	**Value**	**Parameter**	**Value**
radius «a» (um)	200	Number of bunches	4
radius «b» (um)	700	beam energy (MeV)	~ 75
radius «c» (um)	900	Distance between bunches (cm)	0.144
Frequency mode TM01 (GHz)	155.4	Dielectric «ε»	3.8
Frequency mode TM02 (GHz)	359.2	Radius of the ring (um)	250
Frequency mode TM03 (GHz)	531.2	Longitudinal beam size (um)	100
Frequency mode TM04 (GHz)	798.3	Charge (nC)	1
Waveguide length (cm)	10		

Results. We have performed the simulation the simulation for the given bunches and waveguide parameters. Figure 2 is a graph of the resulting field Ez, formed after a sequence of four circular bunches propagating from right to left.

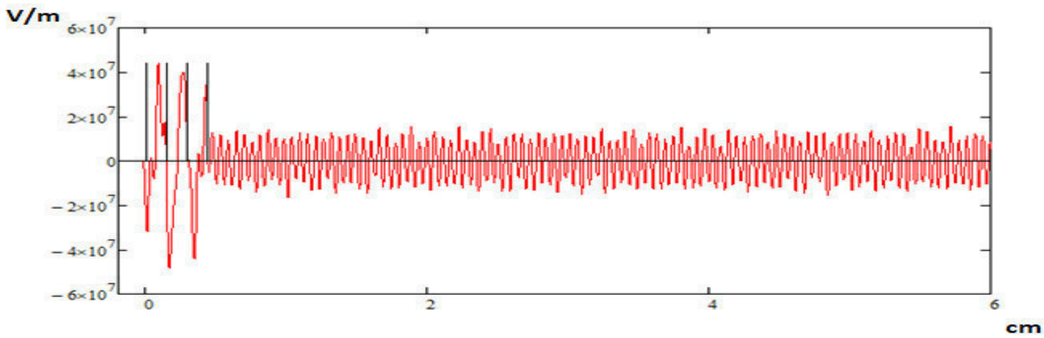

Fig. 2 - Field Ez (THz radiation based on TM03 mode), formed after a sequence of four bunches separated by distance 0.144 cm.

It can be seen from the figure that the wavelength of the radiation wave packet is 6 cm. We have performed the Fourier transform and obtained the resulting spectrum shown in Figure 3

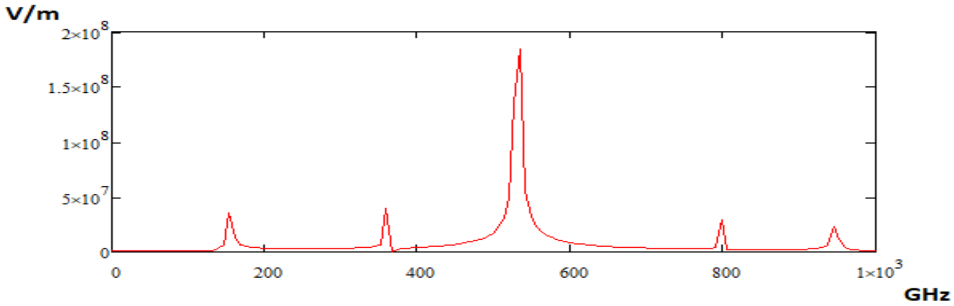

Fig. 3 - Total radiation spectrum

We have determined the degree of the degree of monochromaticity of m as the ratio of the amplitude of the excited mode to the sum of all the amplitudes of the spectrum:

$$m = \frac{\mathrm{TM}_{03}}{\mathrm{TM}_{01} + \mathrm{TM}_{02} + \mathrm{TM}_{03} + \mathrm{TM}_{04}} = \frac{1.84 * 10^8}{3.58 * 10^7 + 3.93 * 10^7 + 1.84 * 10^8 + 2.86 * 10^7} = 0.64$$

Conclusion. In the present work we have carried out a study of the process of generation of terahertz radiation by a sequence of annular bunches in a multilayer dielectric waveguide. For the resulting radiation, parameters such as frequency and degree of monochromaticity were determined. It was found that this ring generation scheme was more stable, in comparison with the classical scheme using simple Gaussian beams in a dielectric waveguide with a vacuum channel, and therefore it didn't require the presence of a focusing system. Therefore, this type of generation can be an economically more advantageous solution.

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