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THE IMPACT OF METAL-DIELECTRIC LAYER ON WAVE PROCESSES IN THE ELECTRODYNAMIC SYSTEM OF AMPLIFIERS BASED ON SMITH-PURSELL EFFECT

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The linear theory of amplifiers applying the Smith-Pursell effect is extended to the impact of metal-dielectric layer and of electron flow thickness on the oscillation excitation conditions in an open waveguide. The wave processes in the amplifier electrodynamic system are investigated theoretically and by experimental simulation.

The possibility of energy exchange between electrons and the field of an open waveguide (OW) diffracted on a periodic structure was shown in [1, 2]. Subsequent theoretic and experimental inquiries in the wave processes in an OW, formed by a periodic structure and a metal screen, showed the advantages of using such system for amplification of electromagnetic oscillation in the diffraction radiation conditions (the Smith-Pursell radiation) [3, 4].

In the last few years, great interest is being shown in VHF application of metal-dielectric structures of various modifications. These structures can be used for improvement of efficiency of energy interchange between electron flow (EF) and high-frequency fields, and for energy extraction in electrodynamic systems of diffraction electronic devices [3, 5–8]. Because of this, of interest is investigation of the model of the amplifier using the Smith-Pursell effect, whose electrodynamic system includes a periodic metal structure and a metal-dielectric layer (MDL).

In this work we perform analysis of the amplifier dispersion equation set up within the limit of the linear self-congruent problem of electronics. Also, we present the results of experimental simulation of wave processes in an open waveguide with metal-dielectric layer.

Analysis of the dispersion equation. The model of the system under investigation is shown schematically in Fig. 1. The open waveguide is formed by two parts at the distance *s* from each other: a comb-shaped structure *1*, with its period $2l$, space width and depth between teeth — $2d$ and h, respectively; and a metal-dielectric layer *2* with its thickness $\Delta = H - s$. The band-shaped nonrelativistic EF *3* of a finite thickness $(r - b)$ is moving along the $0y$-axis at the distance b from the "comb". During the experimental simulation, EF was replaced by a planar dielectric waveguide, whose surface wave represented a radiation source. The lines with arrows show possible variants of radiation directions in vacuum and dielectric in the course of simulation.

The treatment of the self-congruent electrodynamic problem was carried on by the method of partial domains in combination with the Fourier method, which had been used for development of the theory for a system without dielectric layer [4]. As a result, the following dispersion equation was derived:

$$1+\frac{k}{ld}\tan kh\sum_{n=-\infty}^{\infty}\frac{\sin^2\alpha_n d}{\alpha_n^2}\left[\frac{\Gamma_n\left(\cos\left(\xi_n\Gamma_n(r-b)\right)+\sin\left(\xi_n\Gamma_n(r-b)\right)\Pi\right)}{\Pi-\sin\left(\xi_n\Gamma_n(r-b)\right)}\right]=0 \quad (1)$$

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