ELECTRODYNAMIC CHARACTERISTICS AND INTEGRAL MODELS OF A HIGH-FREQUENCY CAPACITIVE DISCHARGE WITH LARGE-AREA ELECTRODES [[1]](#footnote-1)\*)

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An analytical study of the electrodynamic properties of a low-pressure capacitive high-frequency discharge (the frequency of electron collisions is much lower than the field frequency) with large-area electrodes when excited by an electromagnetic field with a frequency of more than 13 MHz was made. The discharge is maintained by surface waves, propagating along the plasma – sheath – metal interface and by higher nonpropagating modes. The sheath is considered within the framework of the matrix model, dispersion curves for even and odd surface waves in a three-layer structure: sheath – plasma – sheath surrounded by metal boundaries are calculated.

For a discharge that completely or partially fills the discharge chamber, analytical calculations of the field showed that the representation of the field as a sum of surface and nonpropagating eigenmodes of E-waves makes it possible to correctly explain the behavior of the impedance. In the standard case of local excitation of the electromagnetic field (at the interface between the electrode and the vacuum chamber), transmission lines corresponding to the excitation of the same types of modes in the central and peripheral regions are connected in series, and the transmission lines corresponding to the excitation of different modes are connected in parallel.

Comparison with numerical calculations, performed in COMSOL Multiphysics® software, showed satisfactory agreement. The electron densities in plasma at which resonance is observed are in most cases calculated in the analytical model with an accuracy of ± 10%.

In accordance with the general expression for the impedance, taking into account both propagating and higher types of modes, as well as currents in the supply transmission line, two types of resonances in the discharge can be distinguished – "global" resonances of current and voltage associated with the compensation of the system as a whole and local resonances associated with an increase in the amplitudes of individual electrodynamic modes. Local resonances manifest themselves as an increase in the absorption of the field at the electron densities for which resonance is observed. To calculate the current-voltage characteristics of the discharge, the solution of Maxwell's equations was supplemented by the equations of the integral balance of particles and energies in the discharge.

The results obtained indicate the possibility of controlling the spatial distribution of the electromagnetic field supporting the plasma, and, consequently, the spatial distribution of the electron density due to the spatial arrangement and configuration of the electromagnetic field excitation region in the discharge chamber [1 – 3].

References

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1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLVIII/Pt/ru/GD-Dvinin.docx) [↑](#footnote-ref-1)