OPTIMIZATION OF THE CHARACTERISTICS OF PLANAR INDUCTIVE ANTENNA FOR HF DISCHARGE EXITATION

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Inductive HF plasma sources [1, 2] have been used in microelectronic technology as alternative to capacitive source types almost immediately after plasma technologies had been used for microprocessor production. In practical constructions different types of antennas for discharge excitation were suggested and realized. Also their characteristics were investigated for simple form of antenna conductors (for example, circle). However, researchers weren’t paid due attention to theoretical calculation of characteristics of antennas and optimization of their form.

In this work we have done the analysis of antennas characteristics, based on representation of field in plasma source in the form of eigenmodes [3, 4]. Source is supposed to be partially filled with plasma. Waves (surface and volume) spectrums, which can be excited in various ranges of frequencies (10 MHz – 3 GHz) in the system and resonant frequencies of the camera at the working density of electrons (109 – 1012 cm–3) were calculated. In the low pressure discharge it is usually enough to use no more than four eigenfunctions. Further results are given for the cylindrical vacuum chamber which contains plasma and dielectric layer above it.

The analysis of eigenfunction spatial field distribution showed that purely inductive type of the discharge corresponds to discharge supported by a H-wave (in relation to Z-axe) with azimuthal number of m=0. H-waves with m≠0 have radial field component which will excite a capacitor component on a lateral wall. Capacitive discharge corresponds to E-wave excitation. However this wave always contains also a tangential electrical component and it can't be excited in pure form. The tangential component is small for the central regions of the discharge and also in case of the small dielectric area size.

Analytically calculated space field distribution showed that at low frequencies as the inductive discharge has an inductive impedance, and the discharge supported by an E-wave has a resonance when discharge length (on transverse direction) is equal to several half waves of a surface wave. For various modes the discharge resonance is observed at the different plasma densities. At high frequencies resonances are observed both for E-, and for H-waves. Analytical expressions connecting amplitudes of various eigenwaves with a form of conductors of the inductive antenna are calculated. Conditions of minimization and maximization amplitudes of marked modes are received. It is shown that azimuthal symmetric (m=0) inductive mode is excited only by azimuthal current. Z-components of electric current in the antenna excite only electric modes.

Comparison of numerical calculations with analytical ones for azimuthal symmetric modes showed their good accordance.

References

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