THE STRUCTURE OF ELECTROMAGNETIC FIELD IN HIGH FREQUNCY CAPACITIVE DISCHARGE WITH LARGE ELECTRODES

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Capacitive high-frequency (HF) low-pressure discharge (ν<<ω) with large area electrodes (radius greater than 20 cm) when excited by an electromagnetic field with a frequency of 13.56 – 500 MHz in a metal discharge chamber is considered (Fig. 1). The discharge under these conditions is supported by surface waves, propagating along the plasma – space charge sheath – metal interface [1]. The dispersion characteristics of these surface waves are analytically calculated in [2]. The discharge is maintained by the high-frequency field supplied to the active electrode 1 and the substrate holder electrode 2.

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| Space charge sheathes 4 depleted of electrons are located between the plasma 3 and the electrodes 1, 2 and the wall 5. The purpose of this paper is a numerical calculation of the distribution of the electromagnetic field in a vacuum chamber and the current-voltage characteristics of a discharge, when RF voltage is applied to electrodes 1 and 2. A specific feature of this work is the inclusion of discharge excitation asymmetry, which leads to an additional HF current on the side wall and additional ionization in this region [3]. An analytical model for calculating the field distribution and the equivalent circuit of discharge, which allows to calculate the currents on the electrodes and on the side surface are proposed.  | Fig. 1. Typical scheme of the experimental setup. 1, 2 - electrodes, 5 - discharge chamber. U1, U2 – high-frequency generators, Z1, Z2 – their internal resistance. |

The impedance of the discharge in the case of excitation of both surface waves and the amplitudes of each of the waves as well as the high-frequency current to the side wall of the discharge chamber is calculated. The possibility of resonances on the current-voltage characteristic associated with the excitation of in-phase and antiphase surface waves in the active electrode and substrate observation is estimated. Analytical approximations for equivalent scheme elements are proposed. Comparison of discharge characteristics calculated in the analytical model with those obtained by numerical simulation with Comsol Multiphysics showed their satisfactory agreement. In comparison with [4], the plasma inhomogeneity in space and the dependence of space charge sheath length on the discharge voltage and plasma density are additionally taken into account. The possibility of excitation of axially asymmetric waves with an azimuthal number m = 1 is discussed.

The results obtained make it possible to determine the conditions for the optimal excitation of a discharge for the realization of a homogeneous discharge with a high electron density.

References

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