GLOBAL MODEL OF A LOW-PRESSURE HIGH-FREQUENCY CAPACITIVE DISCHARGE WITH A LARGE ELECTRODE AREA [[1]](#footnote-1)\*)

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High-frequency (HF) capacitive low-pressure discharges are widely used for dry etching of thin films and plasma chemical deposition [1–3]. An electrodynamic model of a symmetrical discharge was constructed in [2]. Experiments [3] and numerical calculations [4] have shown that asymmetry can be caused by both asymmetric excitation and spontaneous formation of axial or azimuthal discharge inhomogeneity.

Spontaneous violation of plasma symmetry at low pressures can be associated with the possibility of maintaining the discharge by different field modes, in particular, by changing the ratio of the amplitudes of the even and odd surface waves. The setup geometry for which the model was built is shown in Fig. 1. It was assumed that the RF power is supplied to two electrodes 1 and 2 placed in a vacuum chamber 5. Between the plasma 3 and the electrodes, as well as the chamber wall, there are sheaths 4. It was assumed that their thickness is proportional to the amplitude of the oscillations of the plasma boundary.

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| Fig_Statya_3_2019_3A5A  Setup scheme: 1, 2 – upper electrode and substrate holder, 3 – plasma, 4 – sheaths, 5 – vacuum chamber | The distribution of the electromagnetic field in the plasma was described by the system of Maxwell's equations in the cold plasma approximation, and the plasma was described using the electron gas heat conduction and particle balance equations. To calculate the current-voltage characteristics of the discharge, a global discharge model was constructed, in which the spatial distribution of the plasma was described by two terms describing the uniform distribution of the plasma density and its perturbation due to the inhomogeneity of ionization. The amplitudes of surface waves and higher modes were calculated using relations similar to [2], but |

additionally taking into account the inequality in the thicknesses of the space charge layers and the asymmetry of the fields of even and odd surface waves.

Calculations within the framework of the global model were accompanied by the calculation of the spatial structure of the electromagnetic field and the discharge impedance using the Comsol Multiphysics® program and showed satisfactory agreement.

References

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