Modeling of inductively coupled plasma discharges with additional RF voltage [[1]](#footnote-1)\*)

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Low-temperature plasma is widely used in modern production for processing materials. In microelectronics, in plasma reactors, different technological processes are taking place such as deposition and etching of thin films, alloying, etc. At the moment, an important problem of microelectronics is the study of materials with an ultralow relative permittivity (low-k) [1]. Such materials can reduce the capacitance between the layers in the microchips and thereby increase the clock frequency. Studying the effects of plasma on low-k materials is a relevant task.

In this work, a numerical model of an inductively coupled rf discharge in the drift-diffusion approximation is considered. Also, a simulation of a discharge with an additional rf voltage at the electrode is included. The model takes into account the inhomogeneity of the temperature and the flow of neutral gas. The system of equations includes continuity equations for neutral and charged particles, momentum conservation laws for charged particles (in the drift-diffusion approximation for electrons), energy conservation law for electrons, Maxwell equations, heat balance equations, and Navier-Stokes equations for neutral gas. The geometry, boundary conditions, and plasma parameters correspond to the experimental setup from [1]. A set of chemical reactions for argon is used [2].

The case of additional RF voltage at the lower electrode to the inductively coupled discharge model [3] was considered. In experimental chambers, this allows one to better control the ion energy distribution function (IEDF). After performing calculations in the drift-diffusion model, the obtained electric field E(z, t) was used to calculate the IEDF in a separate kinetic model taking into account collisions of ions with neutral particles by the Monte Carlo method. The Effects associated with the inertia of ions was studied. At high rf voltages, the inertia of the ions can make a significant contribution to the main plasma parameters, such as the electron density and temperature, as well as to the ion flux to the electrode. Thus, the complete equation of momentum conservation for ions was added to the drift-diffusion model [3].

As the results of the calculations, the distributions of the density and temperature of electrons, the electric potential, the ion flux onto the electrode, and also the IEDF for various values ​​of the bias voltage in the geometry of the chamber [1] were obtained. It was shown that the values ​​of the main plasma parameters are consistent with experimental data. Thus, the resulting model can be used for further work with more complex molecular gases.

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References

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1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLVII/Lt/ru/EZ-Kropotkin.docx) [↑](#footnote-ref-1)