Numerical model of a gaseous inductive discharge in oxygen, taking into account the complete scheme of the vibrational kinetics of O2 molecules

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Non-equilibrium low-temperature oxygen plasma has a wide range of applications. The use of such plasma has literally revolutionized many industrial processes such as plasma etching, surface treatment, plasma sterilization and medicine. The study of vibrational excitation and relaxation in oxygen plasma is poorly studied area due to the complexity of experimental methods for detecting the vibrational distribution function in oxygen. New experimental data on the distribution of vibrational excitation in stationary and nonstationary discharges in oxygen was recently obtained [1] and this indicates the need to develop more accurate models to describe the relaxation kinetics of vibrational excitation under conditions of significant gas dissociation and to adapt these processes into complete self-consistent models.

Based on previous work [2,3], a two-dimensional hydrodynamic model was built for a discharge in oxygen. In addition to equations for describing the kinetics of charged particles, the model includes a detailed scheme of plasma-chemical reactions and equations for the temperature and neutral gas flow. Accounting for gas heating is especially important when studying processes in mixtures containing molecular gases [4].

Fig. 1. Comparison of the calculated electron density with experimental data.

The resulting model was tested against theoretical and experimental data in a simple cylindrical chamber from [5]. The concentrations of electrons (see Figure 1), ions and oxygen atoms, as well as electron and gas temperatures were compared depending on the power deposited in the discharge.

To verify the developed model of kinetics, with VV/VT processes involving O2(v) molecules and the processes of VT relaxation on O atoms on experimental data [1], it was integrated into a two-dimensional hydrodynamic model of an ICP. The vibrational distribution function was calculated in low-pressure ICP as well as spatial distributions of plasma parameters (density and temperature of electrons, excited components, neutral gas temperature, etc.), and flows of charged and active neutral particles at the reactor walls.

REFERENCES