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INVESTIGATION OF NEAR CATHODE GLOW DISCHARGE PLASMA IN HELIUM AND ITS APPLICATION IN GAS ANALYSIS

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The paper is devoted to investigations of the non-local negative glow (NG) plasma of a glow discharge in helium at low and high pressures.

The first part of the report presents the results of measurements of the electron energy distribution function (EEDF) using a Langmuir probe at low pressures. It is shown that the temperature of the main group of electrons in the NG plasma is low and amounts to fractions of an eV. The formation of narrow peaks in the fast part of the EEDF from fast electrons produced in the reactions of Penning ionization of impurities of air molecules by metastable helium atoms is demonstrated.

In the second part of the report, the possibility of using a wall probe to measure the fast part of the EEDF in a non-local near-cathode plasma at medium and high pressures is substantiated and a formula is obtained that relates the electron current density per probe to the spectrum of fast electrons [1]. The results of registration of air impurities in helium in a discharge structure with flat electrodes at medium pressures and in a discharge with microhollow electrodes at atmospheric pressure are presented. It is shown that in microdischarges with a hollow cathode, by limiting the outer part of the cathode, it is possible to achieve that the wall electrode is located directly in the negative glow region with a low electron temperature in a larger range of discharge currents, while simultaneously increasing the sensitivity in determining the spectra of fast electrons from the Penning ionization of impurities by metastable atoms of helium [2].

The third part of the report demonstrates the possibility of detecting impurities of complex molecules: hydrocarbons, alcohols, ammonia in the near-cathode plasma of a glow discharge in helium at low pressures [3].

In the fourth part of the report, a self-consistent hybrid model of a near cathode negative glow plasma is formulated, including the Boltzmann kinetic equation, written in the f_0-f_1 approximation in the variables «spatial coordinate - kinetic energy», and systems of one-dimensional drift- diffusion equations for a positive ion, excited atoms, as well as the Poisson equation to determine the self-consistent electric field in plasma. Numerical experiments were carried out for helium and argon at low pressures. Numerical experiments have shown satisfactory agreement with the experimental results on the temperature of the main group of electrons and the concentration of charged particles. At the same time, it was shown that the results of numerical calculations in modeling the near-cathode negative glow plasma differ significantly from the results of numerical calculations carried out in the framework of the extended fluid description with the Maxwellian EEDF and with the EEDF obtained in the framework of the iterative solution of the local kinetic equation with a system of fluid equations. Additionally, numerical calculations were carried out on the formation of narrow peaks on the EEDF and on the differential flux from fast electrons produced as a result of Penning ionization reactions of metastable helium atoms of methane impurities and radicals. The minimum impurity concentrations that can be detected by plasma electron spectroscopy have been determined.

REFERENCES

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