Kinetics of fast electrons in a negative glow plasma in a glow discharge in helium at low and high pressures and its application in analytics [[1]](#footnote-1)\*)

DOI: 10.34854/ICPAF.2023.50.2023.1.1.148

Saifutdinov A.I.

Kazan National Research Technical University named after A.N. Tupolev - KAI, as.uav@bk.ru

An important problem of modern gas-discharge plasma physics from the fundamental and applied points of view is the study of near-cathode glow discharge (GD) plasma in a wide pressure range. As is known, two plasmas differing in their properties are generated in the GD: near-cathode plasma, which includes the plasma of the negative glow (NG) and Faraday dark space (FTS) and the plasma of the positive column (PC) [1,2]. Compared to PC, plasma NG and FTS have been neglected for a long time [1,2]. Despite this, for discharges at low pressures, it was found that the plasma in the NG is formed by a beam of fast electrons that has gained energy in the cathode layer and, thus, the ionization source is nonlocal [1, 2]. In this case, the temperature of the main group of electrons, in contrast to the PC plasma, is low and amounts to tenths of 1 eV. In addition, the electron distribution function (EDF) in the NG and FDS plasma is nonlocal. These features opened up the possibility of identifying impurities in the buffer helium in the plasma of the NG of a short GD by recording the spectra of fast electrons that appeared in Penning ionization (PI) reactions.

The aim of the presented work was to carry out numerical and experimental studies of the short GD plasma at low and high pressures. A self-consistent hybrid model of short GD in helium was formulated. It is based on the Boltzmann kinetic equation, the written two-term approximation, the fluid description of the heavy plasma component, the Poisson equation and the heat equation. Elementary processes took into account the formation of singlet and triplet states of the helium atom, the metastable level of molecular helium, and the atomic and molecular helium ions. The set of plasma-chemical reactions was compiled from works [3,4]. On the basis of the formulated model, numerical calculations were carried out at pressures from 300 Pa to 60 kPa. The results demonstrated the OS plasma parameter distributions consistent with the experiments. On the isotropic and anisotropic parts of the EDF, the formation of narrow peaks from characteristic electrons produced as a result of PI metastable helium atoms and impurities of atomic and molecular gases (Ar, N2, O2, and CO2), hydrocarbons (СH4 and C2H5OH), their derivatives was shown. Numerical analysis made it possible to determine the sensitivity of the method for detecting impurities in NG plasma. It was one hundred thousandth, which corresponds to modern mass spectrometric methods. Verification of the simulation results with the results of calculations using the PIC/MCC model [3] and validation of the model with our own probe studies showed good quantitative agreement.

References

1. Rayzer, Yu.P. Physics of gas discharge / Yu.P. Raiser. - Dolgoprudny: Intellect, 2009. - 736 p. [on Russian]
2. Kudryavtsev A.A. Glow discharge physics: textbook / Kudryavtsev A.A., A.S. Smirnov, L.D. Tsendin - St. Petersburg. Lan, 2010.-512 p. [on Russian]
3. Kutasi K., et al.// Plasma Sources Sci. Technol. 2005. 13, S1-S8.
4. Deloche R. et al. // Physical Rev. A. 1976. 13. 3. P 1140-1176
1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/L/Lt/ru/HR-Sayfutdinov.docx) [↑](#footnote-ref-1)