Ambipolar transport in the gas discharge plasma structure

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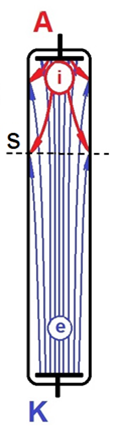
Sunce the first systematic studies of the beginning of the last century, the concept of local ionization-recombination equilibrium is dominant in describing the balance of charged particles of gas discharge plasma. Calculations of the characteristics of gas discharge plasma are based on models of local equilibrium [1], whereas fields observed experimentally at high pressures that are low for ionization are explained by the multi-stage processes of particle production in the bulk [1, 2]. However, electron and ion fluxes coming from the near-electrode layers at moderate and, especially, atmospheric pressures, are sufficient to ensure the balance of particles in the discharge plasma without ionization in the bulk [3]. Moreover, if we consider the motion of charged particles of the positive column in detail, it is easy to see that even in a classical discharge at low pressures (0.01–1 Torr) particles with different signs of charges recombining on the walls in the selected tube cross-section (S) come from different parts of the discharge (Fig. 1). The positive ions (i) moving in the cross-section under the action of ambipolar diffusion simultaneously have a velocity component directed from the anode. The electrons (e) coming to the tube walls together with these ions arrive from the cathode side, and the overwhelming number of electrons generated in the cathode layer pass through the entire tube volume to the anode practically without losses. Only at low pressures (of the order of 0.01 Torr and less) the areas of generation and death of particles can be comparable with each other, although this is also quite questionable, since the mean free path becomes comparable to the radius of the tube and the physical meaning of the concept of local balance is lost.

Fig. 1 Diagram of the motion of charged particles in a tube.

In our papers we show [4–7] that at moderate and atmospheric pressures not only fluxes from the electrode side determine the longitudinal structure of the discharge, but also the plasma transfer as a whole [8], together with the thermal potential *nT* and the plasma electric field energy potential *ρφ* determine the transverse structure of the discharge. Moreover, bulk ionization and recombination losses are not considered. It is shown that the atmospheric pressure stationary discharge [9, 10] exists only in a well-heated gas when molecular ions are absent and the losses are determined by ambipolar diffusion [11].

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References

1. Smirnov B.M. UFN, 2009, 179, 591.
2. Becker K.H. IEEE Transactions on Plasma Science, 2009, 37, 711.
3. Velikhov E.P., Golubev V.S., Pashkin S.V. UFN, 1982, 137, 117.
4. Ivanchenko A.I., Medvedev A.É. J. Appl. Mech. Tech. Phys., 1991, 32(1), 9.
5. Medvedev A.E. Russian Phys. J., 2012, 55 (4), 389.
6. Medvedev A.E. EPJ D, 2016, 70, 37.
7. Medvedev A.E. Proc. of SPIE, 2018, 106141, 106141W-1.
8. Smirnov B.M. UFN, 2008, 178, 309.
9. Arkhipenko V.I., Kirillov A.A. et al. EPJ D, 2012, 66, 252.
10. Staack D., Farouk B. et al. Plasma Sources Sci. Technol., 2008, 17, 025013.
11. Akishev Yu., Grushin M., Karalnik V. et al. Phys. D: Appl. Phys., 2010, 43, 215202.