Scenarios of transitions between different burning modes of DC microdischarges

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Direct current gas discharge is an open system that is far from thermodynamic equilibrium. Due to the presence of the near-electrode layers and the nonlinear nature of the processes occurring in it, many unstable states are manifested and self-organization of various dissipative structures occurs [1,2]. These processes are determined by some critical values ​​of control parameters, both external and internal, depending on the properties of the medium. The development of instabilities, especially near critical currents, often qualitatively and quantitatively changes the structure of the discharge, leading to new combustion regimes. It is worth noting that the discharge of atmospheric pressure is characterized by a fairly rapid heating of the gas to significant temperatures at low currents. In this case, a glow discharge without proper cooling of the electrodes quickly contracted and passes into an arc.

The qualitative picture of the current-voltage characteristic of a low-pressure gas discharge is given in many monographs on plasma physics, which describes the different burning modes of discharges and transitions into each other. However, its full qualitative projection on the behavior of discharges of atmospheric pressure is not obvious. It is clear that it is impossible to model DC discharges in a wide range of discharge currents with a description of the nucleation and formation of various types of instabilities without considering the processes occurring at the “gas-discharge plasma-electrode” boundary.

Therefore, in this work within the framework of a single extended fluid model, various modes of burning of DC discharges are numerically studied in a wide range of discharge currents and various scenarios of transients and formation of current spots on electrodes are described.

In particular, results were obtained that demonstrate different scenarios for the transition from a normal glow discharge to an arc: with a section on the I – V characteristic corresponding to the anomalous glow discharge and without it. The variants are demonstrated in which round, ring and their combination current spots on the electrodes in the normal mode of burning discharges are realized. For the arc mode of discharge, the results with diffusion and contracted current spots on the cathode are presented, depending on the cooling options.

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References

1. Yu.P. Raiser, Gas Discharge Physics, Moscow: Intellect, 2009.
2. M.S. Benilov, J. Phys. D: Appl. Phys. 41 144001, (2008).
3. A.I. Saifutdinov, I.I. Fairushin, N.F. Kashapov. Analysis of various scenarios of direct current microdischarges at atmospheric pressure // JETP Letters, (2016), 104: 180