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NUMERICAL SIMULATION OF DISTRIBUTION OF ELECTRIC FIELD AND PARTICLE TRAJECTORIES IN ELECTRON SOURCES BASED ON HIGH-VOLTAGE GLOW DISCHARGE

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A new method is suggested for numerical simulation of self-congruent electron-ion optics in electron sources based on high-voltage glow discharge. The method uses the tubes of current and permits to consider the impact of recharges and the spread of electrons in velocities on the focal energetic parameters of the shaped electron beam. The simulation results are included.

The sources of electrons based on high-voltage glow discharge (HVGD) with anode plasma have found application in welding, soldering, and annealing of small-size articles in electronics and instrument-making industry, in coating with thin films of complex chemical constitution including gaseous components, in metallurgy, machine-building etc. [1–4]. This is related to advantages of HVGD over traditional thermocathode technologies, particularly, because of stable operation at working pressures from several to several tens of Pascals, relatively simple structure of the cathode assembly, simple control of electron beam power by variation of pressure at a stable accelerating voltage, etc.

However, further development and introduction of HVGD in industry is hampered by complexity of analysis of its electron optics, since the position and shape of the anode plasma boundary has a strong impact on trajectories of the charged particles. In addition, the energy parameters of the electron beam to be formed depend on the spread of electrons in their velocities when they are emitted from the cathode surface due to ionic bombardment. For actual HVGD, treatment of the self-congruent problem of search of electric field distribution in the domain of cathode potential drop, and determination of the shape and boundaries of the anode plasma represents a difficult task if resolvable at all [2, 3, 5]. Because of this, for simulation of electron-optical systems of HVGD (HVGD EOS) one can apply a theoretic-and-experimental method, when the position and shape of plasma boundary is outlined from photographs of the discharge gap, and then use the obtained data for computer-aided simulation of the self-congruent electron-ionic optics of HVGD [3].

In the present paper we consider a method of simulation of HVGD EOS, in which we assume that the plasma boundary in the large discharge current conditions is parallel to the cathode surface [2, 3]. The plasma potential and the position of its boundary are calculated based on the discharge existence conditions. Then the plasma is considered as the electrode transparent for electrons with some known magnitude of potential. All this makes it possible to calculate particles' trajectories in the domain of the cathode potential drop with the space charge taken into account, and to locate the focus of the formed electron beam, situated in the anode plasma domain. When calculating trajectories of electrons, we also consider their spread in velocities during emission from the cathode surface.

Since in HVGD the density of electron flow from the emitter is relatively low (not exceeding 10^5 A/m^2) [1, 2], one of the main features of electrode systems of industrial gas-discharge electron sources consists in usage of cathodes with well-developed emission surface. Because of this, HVGD EOS cannot be regarded as paraxial, and for their numerical

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