EXPERIENCE OF FORMATION OF COMBINED LOW ENERGY ELECTRON-ION BEAMS IN PLASMA SOURCES OF CHARGED PARTICLES

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One of the methods to increase the efficiency of ion sources used for deposition of thin-film layers of metals, semiconductors and dielectrics is the use of high-current electron emitters to support ionization processes and ensure stable discharge burning, compensation of both the volume charge in the beam, and the surface charge on the formed film. Currently, thermal emitters are used for these purposes [1]. However, under conditions of intense ion fluxes, the resource of such emitters is limited due to intense ion bombardment. Therefore, the search for these purposes of non-termal emitters of electrons is quite relevant. Low-energy electron beams are also of interest for the implementation of plasma-chemical processes and technologies for deposition of films and coatings for various purposes using alternate or simultaneous thermophysical electron and modifying ion effects.

In systems with a plasma emitter, the production of low-energy compensating electron beams is possible either due to energy recovery or by creating optimal conditions for the formation of such beams directly at the source. In the formation of electron beams of the required geometry in systems with a plasma emitter, the position and shape of the emitting plasma surface are decisive. They, in turn, are determined by the plasma parameters, the characteristics of the beam-forming system (the potential and geometry of the forming electrodes), and the magnitude of the reduced field strength accelerating the electrons.

The paper shows the possibility of forming combined electron-ion beams in a single multi-bit structure that does not contain incandescent elements. The design of the electrode structure of an electron-ion source, consisting of two gas-discharge cells of the "Penning" type [2] connected in series (along the axis), is proposed. It is shown that the interrelation of separately controlled discharges in the structure contributes to an increase in the degree of gas ionization under reduced pressure, as well as to the formation of double electric layers in the plasma, ensuring the formation of combined ion-electron flows in a single structure. This is achieved by creating conditions for the electron beam to drift through the entire part of the electrode structure, which ensures the formation of the ion current of the source, and contributes to an increase in the degree of gas ionization in this region. In addition, the deceleration of the electron beam in the gap of ion acceleration ensures the return of electrons that have lost some of their energy to the ionization of the gas to the region of the formation of the ion-emitting plasma. This contributes to an increase in the density of the ion emission current.

The possibility of separate control of the accelerating voltages of electrons and ions in the developed structure provides for regulation in a wide range of ratios of the energies of electrons and ions, as well as the densities of their currents in the electron-ion beam. This expands the range of possible technological application of the electron-ion beam source.

The results of the research indicate the promising application of the developed structure for the design of technological sources of combined electron-ion beams.

REFERENCES

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[2] *Penning FM. "Coating by cathode disintegration", US patent 2,146,025, N.V. Philips, Gloeilampenfabrieken, Eindhoven, The Netherlands, 1939.*