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DISCHARGE SYSTEM WITH ELECTRON OSCILLATIONS IN THE EMISSION REGION FOR THE POSITIVE ION SOURCE

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Design of the discharge system with electron oscillations in the emission region for the positive ion source was studied. Realization of the conditions for electron oscillation in the emission region of the electrode system allowed to increase the energy efficiency of a glow discharge. Obtained characteristics of the discharge with electron oscillation in the emission region of the discharge chamber allow to conclude about possibility of its application in the positive ion source operating at low pressure in the discharge chamber.

Keywords: *DISCHARGE CHAMBER, GLOW DISCHARGE, POSITIVE IONS, ION BEAM, ION SOURCE*

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1. INTRODUCTION

Glow discharges, because of the burning stability at current densities on the cathode up to tens A/cm^2 and the simplicity of their technical realization, are attractive for application in plasma sources of charged particles. The main problem arising from such application of glow discharges consists in the necessity of the gas pressure decrease in the discharge chamber below 10 Pa for providing the electric strength of acceleration gap. The solution of this problem is achieved using the specific form of glow discharge optimized for the negative ion generation [1].

But the radial distribution of the plasma density in the emission region of this discharge system was specially made in such a way that the minimal plasma density was on the axis. Physical ideas about the processes, which take place in similar discharge system, are considered in [2], and the discharge system itself is schematically represented in Fig. 1. In the case of the positive ion extraction such distribution of the plasma density is not the optimal one.

2. EXPERIMENTAL RESULTS AND DISCUSSION

To produce the positive ion source the discharge system developed earlier for the negative ion source was changed. In the present work we discuss the results of the first experimental investigations of the modified electrode system for the positive ion generation. Structural diagram of this discharge system is represented in Fig. 2.

Plasma is generated in the double-chamber (chambers 5 and 6) inverse gas magnetron, where both the magnetic and the electrostatic fast electron confinement occur. As the result, their staying time in the magnetron chambers is large and they can make a sufficient number of ionizations for keeping the discharge. Both discharge chambers are hooked up parallel to the one power source. Potential difference between the electrodes of the discharge system is assigned by the automated displacement on resistances, as shown in Fig. 2.

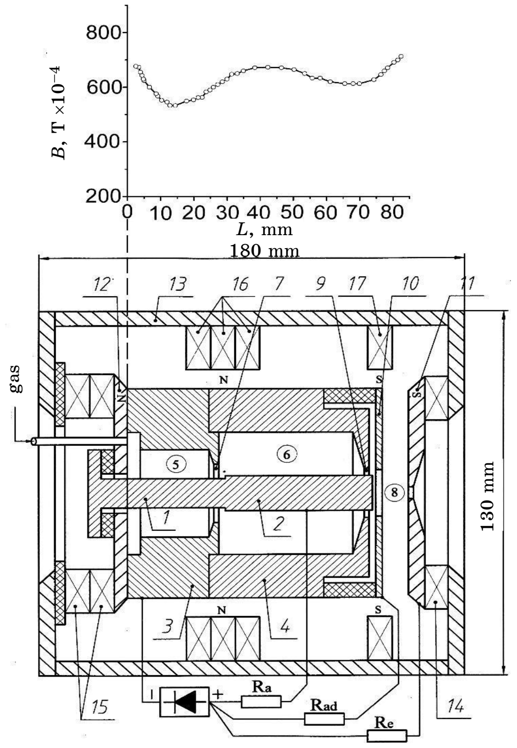

Fig. 1 *– Design of the electrode system and the axial distribution of magnetic strength in a pole gap: 1, 2 – anode; 3, 4 – cathode; 5, 6 – chambers of high and low pressure, respectively; 7, 9 – contracting annular channels; 8 – emission chamber; 10 – biased anode; 11 – emission electrode; 12 – lower pole; 13 – magnetic circuit; 14, 15, 16, 17 – Sm-Co5 magnets*

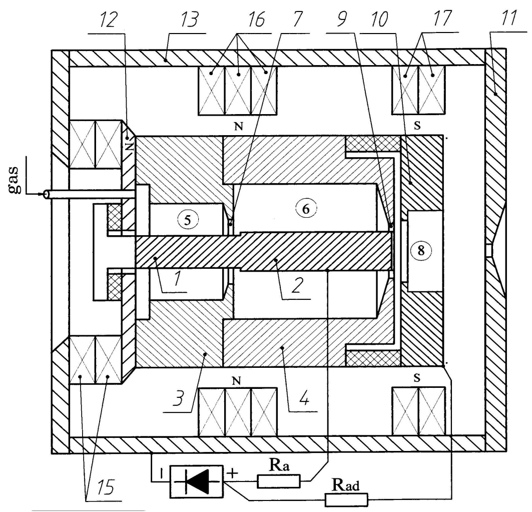

Fig. 2 *– Design of the discharge system with electron oscillation in the emission region*

The main differences of the present electrode system from the one used by us in the negative ion source and described in [2] consist in the following:
1. Emission electrode 11 is under the cathode potential, and the mode of electron oscillation in the emission chamber 8 is realized there, that gives a possibility to increase the energy efficiency during the positive ion extraction from plasma.
2. Geometry of the biased anode 10 is modified, and being of such design it is the main anode (MA) of the discharge system.

Known, that in glow discharges with electron oscillation there is a group of fast electrons, and though their fraction is not large, but precisely their contribution to ionization is the main one [3]. Thus, one can expect the increase of the discharge efficiency.

In Fig. 3 we present the diagram of the stretched on MA-to-the total discharge current ratio $k = I_{MA}/I_d$ versus the total discharge current I_d for the discharge with electron oscillation (Fig. 2), and the dependence of the stretched on emission electrode (EE)-to-the total discharge current ratio $k = I_{EE}/I_d$ versus I_d for the discharge without electron oscillation (Fig. 1).

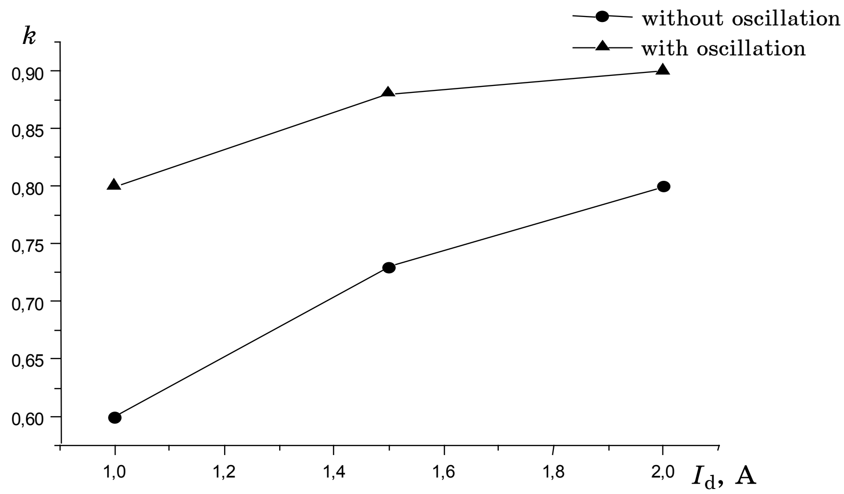

***Fig. 3** – Dependences of the current ratio k versus the total discharge current*

The working pressure was $P = 3{\cdot}10^{-2}$ Pa for the both cases. As seen from the diagram, discharge in the electrode system with electron oscillation in emission plasma has the greater energy efficiency.

In Table 1 we represent values of the discharge voltages with electron oscillation U_{osc} and without it $U_{w.osc}$ at two values of the discharge current and working pressure in the discharge chamber $3{\cdot}10^{-2}$ Pa and $2{\cdot}10^{-2}$ Pa.

Analysis of the Table 1 shows that the values of voltage drop on the discharge interval in the modified electrode system have lower magnitudes in comparison with the analogue both at different values of the working pressure and at different values of the discharge current. This fact also confirms the great energy efficiency of the electrode system with electron oscillation, based on which it is proposed to produce the positive ion source.

Table 1 *– Comparative characteristics of the discharge voltages with and without electron oscillation*

U_{osc}, V	$U_{w.osc}$, V	I_d, A	P, Pa
380	405	1,0	$3 \cdot 10^{-2}$
390	420	1,5	
395	420	1,0	$2 \cdot 10^{-2}$
410	435	1,5	

We also have to note, that in some experiments we have observed the strong increase of the voltage drop on the discharge interval 8 at the pressure decrease lower than the certain critical value. A glow discharge was almost transformed into the high-voltage form. The same phenomenon takes place when the gap length between the cathode end-plane 4 and the electrode 10 increases. These two causes can be used in future for the maintenance of the high-voltage form of a glow discharge, for example, during the generation of double-charged ions.

Increase of the plasma density on the axis of the emission region of the electrode system can be achieved due to magnetic compression as it has done in [4]. The required configuration of magnetic field lines along the system can be obtained varying the number and the disposition of the beam-positioning magnets along the magnetic circuit 13. Later on it is necessary to use the water-cooling of the anode 10 as well.

3. CONCLUSIONS

Thus, based on the prior experimental results obtained we can conclude the following:

– creation of conditions for electron oscillation in the emission region of the electrode system allowed to increase the energy efficiency of a glow discharge;

– obtained characteristics of the discharge with electron oscillation in the emission region of device allow to conclude about its application in the positive ion source operating at low pressure in the discharge chamber;

– glow discharge burning with electron oscillation is possible in two forms: the high-voltage and the high-current. The high-voltage form of a glow discharge can be used during the generation of the double-charged ions.

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