THE FORMING SYSTEM SIMULATION FOR REACTIVE GAS ION SOURCE WITH DECREASED NEUTRAL GAS INLEAKAGE

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This report is devoted to research of possibility of acceleration N ions with original system of ions extraction and acceleration. The simulations of its electrode geometry for nitrogen ions acceleration are described. The parameters of its optimization for nitrogen ions acceleration are described. Comparison of the simulation results with the experimental dates was done.

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INTRODUCTION

The ions beams are used in the advanced industrial technologies to change the form and to modify the physical, chemical, electric and magnetic properties of the processed products surface. An applied plant project based on the reactive gases ion source is considered in the work [1]. The accelerated beam properties are described. The work describes the possibility of use for physical research in the NSC KIPT. The experiments with 50 keV reactive gas ion beam acceleration were carried out at different ion source designs and described in the literature [2]. The same forming system used for calculation the accelerated beam properties. The purpose of numerical settlements to check the electrode size and place taking into account the space charge of the beam and the breakdown voltage and to determine the optimal voltage distribution on the ion source main electrodes in which ion beam has required cross-size, longitudinal and transversal velocities. There is a reasonably well developed computer calculation code, which facilitates and accelerates the development of the complex geometries electronic-optical systems (EOS).

THE ELECTRON GUN MODEL

The program features a method of successive approximations for solving the system of equations, describing the electromagnetic field and the electron flow. When calculating the density of the space charge is used discrete flow model. Flow represented by a finite number of tubes with constant current, which follows from the continuity equation, used for each current tube. The algorithm that simulates the transition process the system uses to establish a self-consistent state of the flow method relaxation of current injected into the system. Given a current determined by the conditions at the cathode, determined the trajectory of the particles and the distribution of the charge density in the space corresponding to the found particle trajectories. Given the distribution of the charge density determined the potential distribution. Repeating this sequence at each step examined the transition process in the system [3].

It may be as a stationary and periodic or chaotic state of dynamic system in the given external stationary electric or magnetic fields [4].

COMPLEX BEHAVIOUR

Since the process of establishing a self-consistent state step by step, it is appropriate in the method current relaxation use difference equations relating the current density at the (n+1)-th step with the previous n-th step. This relationship is not linear, as for the determination of the current density at given potential distribution use of the law "3/2 power" with limited maximum emitting ability of the cathode to avoid non-physical situations. In Fig. 1, taken from work [5], the example of high perveance electron gun calculation is given.

The program solves the problem of modeling the electron gun with 4 microperveance at 15…20 approximations. Table contains the first 25 steps microperveance values for different values of parameter. It is seen that for values of the parameter less than 0.7 perveance converge to a value of 4, regardless of the parameter setting.

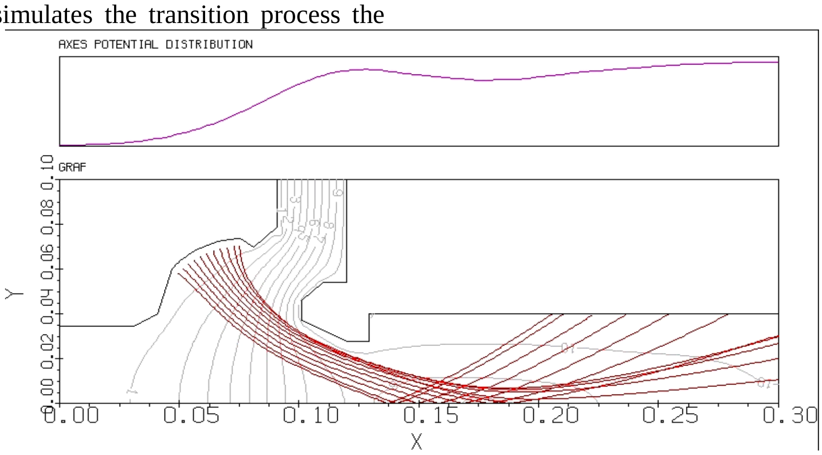

Fig. 1. High perveance electron gun

If the value of parameter 0.7 or more, after a transitional regime perveance oscillates between two values, i.e. instead of steady state system demonstrates cyclical behavior. Perveance experimental sample electron gun coincides with the calculated accurately. This makes it possible to hope for a good accuracy of calculation of ion EOS, which will described hereinafter.

Perveance on the first iterations of a mapping for different values of parameter at an accelerating voltage of 50 kV

n/r	0.1	0.3	0.5	0.7	0.9
1	0.37	1.05	0.37	0.37	0.37
2	1.05	4.43	1.05	9.88	12.6
3	2.18	4.63	6.68	1.14	0.16
4	2.92	4.14	4.23	9.12	14.03
5	3.39	3.75	2.28	1.01	0.07
6	3.67	3.73	4.62	10.49	14.48
7	3.84	3.94	4.06	0.83	0.07
8	3.92	4.06	3.74	11.25	14.5
9	3.95	4.05	3.99	0.68	0.06
10	3.95	4	4.08	11.7	14.5
11	3.95	3.98	3.99	0.55	0.06
12	3.94	3.98	3.97	12.37	14.5
13	3.94	4	4	0.43	0.06
14	3.94	4	4	12.91	14.5
15	3.95	4	399	0.42	0.06
16	3.96	4	3.99	12.65	14.5
17	3.97	3.99	4	0.39	0.06
18	3.98	4	4	12.93	14.5
19	3.98	4	4	0.41	0.06
20	3.99	4	4	12.51	14.5
21	3.99	4	4	0.39	0.06
22	3.99	4	4	12.99	14.5
23	3.99	4	4	0.41	0.06
24	3.99	4	4	0.98	14.5
25	3.99	4	4	0.49	0.06

ION SOURCE SYSTEM

Three-electrode axially symmetric accelerating-focusing system used for the preparation high current ion beam with current over 10 mA and energy over 50 keV. The accelerating electrode and the focusing electrode form should calculated many times. High accuracy is required for the adjustment of the electrodes to repeat the computational geometry. High potential apply between gas discharge chamber body (the first electrode – cathode of ion source) and experiment chamber body (the third electrode) such that the experiment chamber grounded and ion source chamber under high positive potential. The intermediate electrode (the second electrode) was under negative potential 5…10 % from full acceleration potential. Two-potential system provides formation of accelerated ion beam on the desired size of the target in the experimental chamber (Fig. 2).

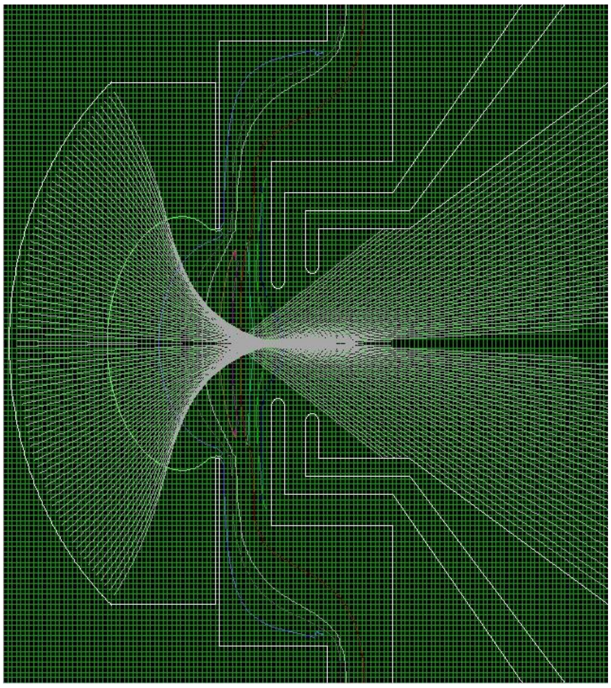

Fig. 2. Formation of the beam two-potential system

CONCLUSIONS

For the design and analysis of axial electro-optical systems with thermionic cathode created "GUN" program. This program solves the problem of the analysis of electronic-optical systems. In the program for given geometry and potentials of the electrodes and the mode of emission from the cathode the charged particle trajectories are determined.

The electrode system of ion source with a small gas inleakage with the energies up to 50…60 keV was calculated. With EOS analysis "GUN" program calculated for configurations matching the ion beam parameters at the outlet for the injection into the working chamber. The accelerating and focusing electrode geometry founded for reception of the beam given parameters. It was shown opportunity improvement quality of a flow by selection the appropriate curvature of emitting surface. The numerical model shows complex behavior at formation self-consistent state the charged particles flow and can used at study of properties complex dynamic systems described by the large number ordinary differential equations.

The calculation results are compared the experimental data from the measurements with decreased leakage ion source.

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ЧИСЛЕННОЕ МОДЕЛИРОВАНИЕ СИСТЕМЫ ФОРМИРОВАНИЯ ИСТОЧНИКА РЕАКТИВНЫХ ИОНОВ С МАЛЫМ НАТЕКАНИЕМ ГАЗА

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Работа посвящена исследованию системы постускорения ионов азота, использованной в прикладном источнике реактивных ионов. Проведены численные расчёты геометрии электродов для получения ускоренных ионов азота. Проводится оптимизация систем ускорения-формирования источника ионов реактивных газов для использования в установке прикладного назначения. Проведено сравнение результатов расчёта с экспериментальными данными.

ЧИСЕЛЬНЕ МОДЕЛЮВАННЯ СИСТЕМИ ФОРМУВАННЯ ДЖЕРЕЛА РЕАКТИВНИХ ІОНІВ ЗІ ЗНИЖЕНИМ НАТІКАННЯМ ГАЗУ

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Робота присвячена дослідженням системи постприскорення іонів азоту, що використана в прикладному джерелі реактивних іонів. Проведені обчислення геометрії електродів для отримання прискорених іонів азоту. Проводиться оптимізація системи прискорення-формування джерела іонів реактивних газів для використання в установці прикладного призначення. Проведено порівняння результатів обчислення з експериментальними даними.