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On Plasma Parameters Determination In Mix Of Argon And Hydrargyrum

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Abstract

Plasma is very widespread state of matter and is widely used in many devices and apparatus; it causes constant interest in its properties study. Famously, electro-kinetic characteristics of plasma substantially are defined by electronic component, and electronic gas state in plasma is described by cumulative distribution function of electrons by speeds. Any explanation of physical processes taking place in plasma demands knowledge of such parameters as temperature and electron concentration. This work is devoted to determination of these parameters in mix of Argon and Hydrargyrum gases. Probe technique determined temperature and electron concentration of positive discharge column in mix of Argon and Hydrargyrum at medium pressure. For the same conditions analytical calculation of cumulative distribution function of electrons by speeds, the mixes of gases considering probability of resilient and inelastic collisions of electrons with atoms is made. By means of cumulative distribution function of electrons concentration, temperature and speed of electron drift are calculated. Results of calculations are compared with the experimental data obtained from probe measurements. As before, the case when in ratio of mixture Hydrargyrum is present at type of small impurity is considered.

Key terms: function, approximation, speed, energy, concentration, temperature, resilient, inelastic, plasma.

Introduction

The probe method of diagnostics developed by Lengmur [1] at the beginning of the century today is one of the main means of gas-discharge plasma parameters determination. Number of reviews and monographs are devoted to this method current state [2-4]. Cumulative distribution function of electrons by speeds were investigated in Argon [5] and Helium [6]. In work [7] electro-kinetic discharge characteristics in mix of Hydrargyrum and Argon at positive pressure of argon were investigated. In work [8], referring to computational method of cumulative distribution function of electrons by speeds, considering resilient and inelastic collisions of electrons with atoms of gases, expediency of similar calculations use for mix of gases parameters determination was noted. As a result, carrying out researches of Argon and Hydrargyrum mix parameters, with application of this method, represents particular interest in current branch development.

Methodology.

The pilot studies of Argon and Hydrargyrum mix parameters were carried out by the probe technique described in previous work [9]. Researches were conducted with pressure of Argon of 1 mm of mercury. and Hydrargyrum of 10^{-3} mm of mercury, respectively. Force of digit current changed within 20150 mA. Analytical researches were conducted by computational method of cumulative distribution function of electrons by speeds, the considering resilient and inelastic collisions of electrons with atoms of studied gases mix.

Results of probe measurements on concentration and temperature of electrons, are given in the table.

Main part.

The kinetic equation for isotropic part of cumulative distribution function of electrons on speeds φo (x), at a constant electric field E, without diffusion, is [10].

, (1)

where, - diffusion length of free run of electrons, - an electron free length, bound to inelastic collisions, e and m - charge and electronic mass, M - the mass of atom. In the equation (1) instead of electron speed υ the variable, where, by Uo = 11,5 eV - the first Argon atomic excitation potential is inserted.

For efficient sections of resilient s and inelastic $s._{n.u.}$ scatterings of electrons atoms of Argon and Hydrargyrum are accepted the following approximations:

for Argon

, (2)

, (3)

for Hydrargyrum

, (4)

Here n_1, p_1 and n_2, p_2 - concentration of atoms and fractional pressure of Argon and Hydrargyrum respectively.

We should note that approximations for Argon (2) are identical to approximations given in work [8].

Linking between efficient section for s momentum transfer * and efficient transverse section of scattering of s we will consider s * = 0,8s [10].

As well as in work [9], we will neglect the section of resilient scattering of electrons with atoms of Hydrargyrum in all interval of change.

According to accepted approximations (2) - (4), (1) we will solve the equation for four areas separately: 0 < *x* < 0,1; 0,1 < *x* < 0,42; 0,42 < *x* < 1 and *x* > 1. In area 0 < *x* < 0,1 equation (1) takes form of

, (5)

where

Equation (5) solution would be

, (6)

where C^1 and D^1 - arbitrary constants.

In area 0.1 < *x* < 0,42 equation (1) takes form of

, (7)

Equation (7) solution would be

, (8)

In area 0,42 < *x* < 1 equation (1) takes form of

, (9)

where

At β2>>; α in the equation (9) it is possible to neglect the second term and to write down

, (10)

Solution of equation (10) is given by expression

, (11)

where $I_\nu(x)$ - Bessel function, $K_\nu(x)$ - McDonald function [11].

In area *x* > 1 equation (1) takes form of

, (12)

where

Substitution leads equation (12) to a form of

, (13)

Neglecting members, small in comparison with, the equation (13) we will paste in the following form

, (14)

The solution of equation (14) addressing in zero at $x \to \infty$, will be

Thus, in area x > 1 we have

, (15)

Constants C_1, D_1, C_2, D_2, C_3, D_3 are defined from continuity of functions condition $\varphi_o(x)$ и $\varphi'_o(x)$ in points $x = 0,1$, $x = 0,42$, $x = 1$. Constant C_4 is derived from function normalization condition $\varphi_o(x)$.

On formulas (6), (8), (11) and (15) calculation of function of distribution of electrons for speeds for mix of argon and mercury under the conditions corresponding to our experiment was made. The knowledge of function of distribution of electrons of speeds gives the chance to define average energy and speed of drift of electrons. For this purpose it is necessary to pass from cumulative distribution function of electrons by speeds φo (x) to cumulative distribution function on energies of F (x) [10].

, (16)

where a - rationing constant.

Then average energy of electrons is defined, as usual, from expression

, (17)

Let's note that for calculation of average energy we will be limited to area x < 1 as F (x) has a maximum at x < 1 and the size of this maximum much more, than F(1) [10] value.

To determine the temperature of received distributions, enter some temperature of T_2, having connected it with average energy of electrons as usual.

Comparison of calculated efficient temperatures of T_2 to temperature of electronic T_1 gas received from probe measurements for various digit currents are provided in the table.

Speed of electron drift is determined by expression

, (18)

Since we had no opportunity to compare results of speed calculation for ū electron drift immediately the experimental data in view of lack of the last only their design values are reduced in the table.

Knowing the speed of ū electron drift and distribution of their concentration it is possible to determine by the section of digit tube n (r), at this digit current, an electron concentration on tube axis by formula

, (19)

where $n(r) = n_o\,\varphi(r)$, $\varphi(0) = 1$, R - digit tube radius.

Calculation results an electron concentration on no tube axis n_1, in designation of n_2, for various values of digit currents are reduced in the table

Calculated and experimental parameters of the Ar-Hg mix .

Table

I, mA	E, In/cm					
36	1.35	25	21	4.6	3	2.4
50	1.28	18	20.6	4.4	5.2	3.5
100	1.25	17.5	20.5	4.3	19	7.2
150	1.13	15	20	4.0	26	11.2

Table shows that there is satisfactory consent of design values of temperature of T_2 and concentration of n_2 of mix with their T_1 values and n_1 received from probe measurements.

Summary. Conducted research analysis shows that parameters of positive discharge column of Argon and Hydrargyrum mix, at medium pressure, with satisfactory accuracy, can be calculated by means of cumulative distribution function of electrons by speeds, the considering resilient and inelastic collisions of electrons with atoms of gases.

Conclusion

Probe method determined temperature and electron concentration in positive discharge column of Argon and Hydrargyrum gas mix. Calculation of cumulative distribution function of electrons by speeds, the considering resilient and inelastic collisions of electrons with atoms of mix is made and average energy, drift speed, temperature and electron concentration are calculated. The calculated parameter values of positive discharge column in mix of Argon and Hydrargyrum are in satisfactory consent with their values received from probe measurements.

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