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STUDY OF PLASMA PARAMETERS IN THE OXYGEN-HELIUM MIXTURE[1])

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Plasma parameters of positive column-electron density, electron collision frequency and axial electric field are determined. All parameters are measured in dependence on the discharge current, pressure and radiation of oxygen: helium in the mixture. Plasma parameters are measured by means of the microwave resonator method.

ИЗУЧЕНИЕ ПАРАМЕТРОВ ПЛАЗМЫ В СМЕСИ ГЕЛИЯ И КИСЛОРОДА

В работе определены параметры плазмы положительного столба: плотность электронов, частота соударений электронов и аксиальное электрическое поле. Все параметры измерены в зависимости от разрядного тока, давления и соотношения количества кислорода и гелия в смеси. Параметры плазмы измерены при помощи метода микроволнового резонатора.

I. INTRODUCTION

The interesting behaviour of the glow discharge of oxygen is a very frequently studied subject in plasma physics [e.g. 1, 2, 3]. The influence of other, mostly inert gases, on the oxygen plasma are studied too. For instance, Seeliger and Wichmann [4] measured the influence of helium on the electric field (respectively on the T and H form in oxygen) for different pressures and different mixtures of oxygen and helium. Recently, both the experimental and the theoretical analysis of this mixture have been studied by Mašek et al. [5]. They determine the distribution function of electrons both experimentally (from probe measurements) and theoretically by means of the Holstein form of the Boltzmann equation. They have also calculated the transport and Towsends coefficients and drift velocity. From all their results it follows that a small admixture of oxygen influences very strongly all these plasma parameters for relative small values of the electric field.

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In our case we studied the positive column of glow discharge in the helium-oxygen mixture from the experimental point of view. The axial electric field, electron density and effective collision frequency of elecrons were determined.

II. EXPERIMENTAL CONDITIONS

All our measurements have been performed in a discharge tube of a U shape, the length of its straight part was 0.4 m, the part with nickel electrodes was 0.1 m long. The discharge tube diameter was 2×10^{-2} m. In the discharge tube there were placed two couples of platinum probes for axial electric field measurements. The electron density and the effective collision frequency of the electrons were determined by means of the microwave toroidal resonator method [e.g. 6].

Measurements of these plasma parameters were realized for such discharge conditions when only a high gradient form (H — form of the positive column) in the pure oxygen exists. The range of the measured discharge currents was 5—30 mA, the range of the used pressures was 60—270 Pa. All measurements were made for different ratios of both gases in the mixture. If we defined the parameter X as $X = p_{02}/p$, where p_{02} is the pressure of oxygen in the mixture and p is its total pressure, the value X varied from 0 to 1.

III. RESULTS OF MEASUREMENTS AND DISCUSSION

The typical dependence of the axial electric field E on the parameter X for all measured pressures and for the discharge current 10 mA is shown in Fig. 1. From this figure it is seen that the value of E is higher for higher pressures and is an increasing function of the parameter X. This effect is more significant for lower values of X. This dependence is the same for other measured discharge currents.

In Fig. 2 the dependence is shown of the reduced electron density on the parameter X for all measured pressures, for the discharge current 10 mA. From

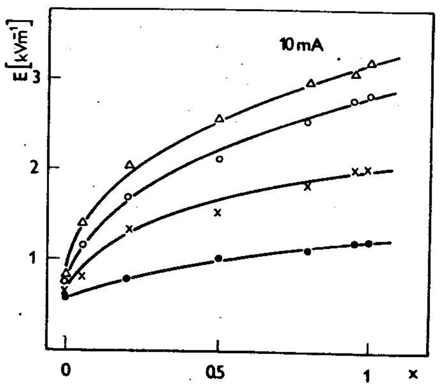

Fig. 1. Dependence of the axial electric field on the oxygen admixture for 10 mA and pressures △ ... 270 Pa, ○ ... 200 Pa, x ... 133 Pa, ● ... 67 Pa.

this typical course it is seen that the most significant change of this plasma parameter is for a small admixture of oxygen 5—10 %. From practically 30 % on the reduced electron density is practically constant.

The results of the electron collision frequency measurement are evident from the Figs. 3 and 4. In Fig. 3 there are shown the experimental points of the measured values of the collision frequency ν on the value E/p for $X = 0.5$ and its

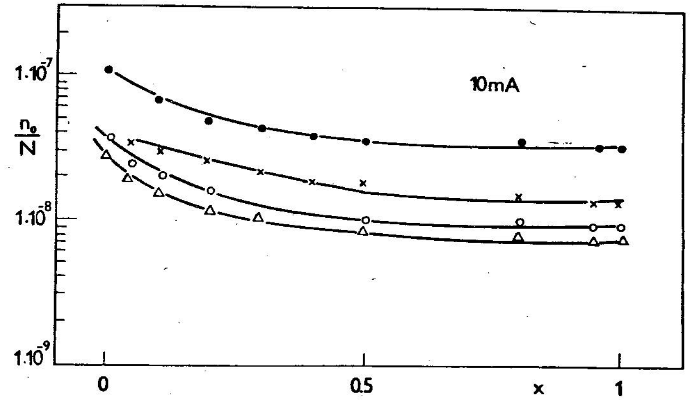

Fig. 2. Dependence of the reduced electron density on the oxygen admixture for 10 mA and pressures △ ... 270 Pa, ○ ... 200 Pa, x ... 133 Pa, ● ... 67 Pa.

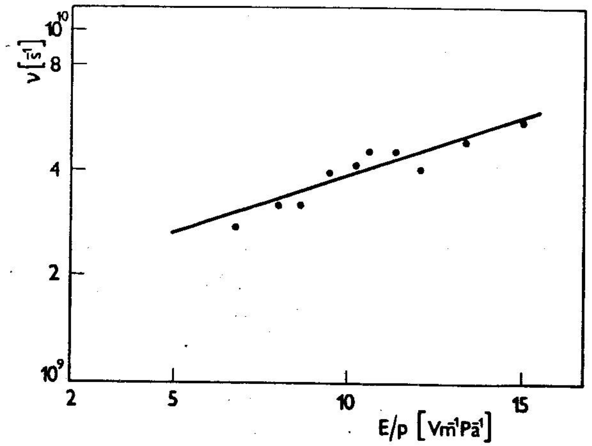

Fig. 3. Electron collision frequency for $X = 0.5$.

approximation by the straight line. Dependences of the ν on E/p for all the measured values of X are plotted in Fig. 4. From this figure it is seen that the collision frequency of electrons is an increasing function of E/p for all the

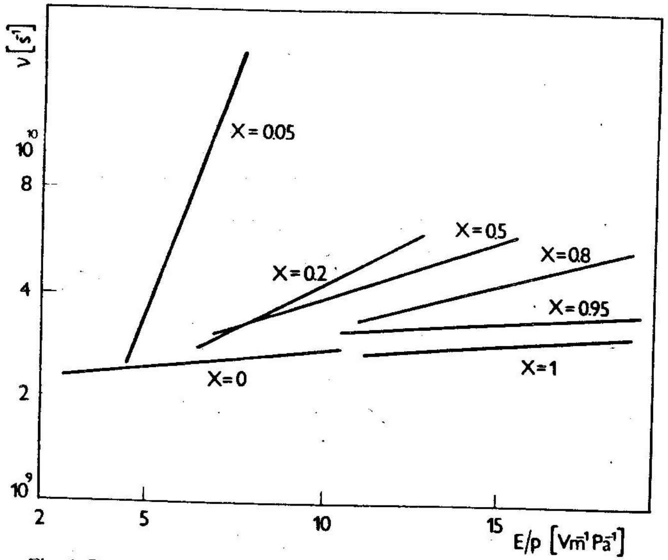

Fig. 4. Dependence of the electron collision frequency on the E/p and X.

measured mixtures (with a small change for pure helium and pure oxygen). A very small admixture of oxygen in helium results in a very strong increase of the electron collision frequency. A similar result was obtained by the numerical solution of the Boltzmann equation [7]). A further admixture of oxygen means a decrease of the electron collision frequency to the value for pure oxygen.

All the measured effects can be explained (similar to the results in [5]) as follows:

A small admixture of oxygen results in the increase of ionization (the ionization threshold of oxygen is 12.2 eV, that of helium 24.5 eV) and also in an increase of ν.

A further growth of the oxygen portion in the mixture results in a further increase of inelastic collisions and in this way the value of the fast electrons decreases [5]. It means that also their average velocity decreases. The electron collision frequency is proportional to this velocity [8] and also decreases.

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