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Double Layer Formation in Argon Glow Discharge

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Abstract

The experimental results are presented on the formation process of the double layers that may appear within transition region between two independent argon glow discharges. Electrical probes and optical spectra were used in order to measure both axial and radial distributions of plasma parameters. One, two, three or even more plasma formations as multiple double layers can be obtained versus experimental parameters.

1. Introduction

A special attention was given to the study of the instabilities, which appear in non-uniform collision plasmas of some regions of the glow discharges. Thus, distinction between instabilities self-excited within positive column, anode glow and/or negative glow of the d.c. discharges plasma were made. Moreover, some mechanisms and theoretical models have been proposed at least for some of these instabilities [1]. One of most difficult problem in the study both experimental and theoretical approach is the contribution of a rather large number of parameters.

To reduce the number of these parameters a new experiment has been proposed by Sanduloviciu and Alexandraoei [2]. It consists of two independent d.c. cold cathode discharges produced in the same cylindrical glass tube but having opposite directions and separated by a free space between their anodes. Applying a d.c potential between the two anodes a new plasma formation may appear within the free space region. This potential can be used as a control parameter for phenomena related to both static and dynamic behaviour of the plasma formation between the anodes.

In this paper the experimental results are presented on investigation of plasma spatial distribution of plasma parameters within the free region plasma for both static and dynamic behaviour of plasma formation.

Experimental set-up and results.

The experimental device is presented in fig.1. A cylindrical glass tube contains the following components: two Aluminium hole cathodes K_1, K_2 (diameter 2.5cm and 3.2cm in lengths); two cylindrical anodes A_1, A_2 (diameter 4.0 cm and 7.0cm in lengths, an emissive probe (P, tungsten wire of 0.2 mm diameter and 3 mm in lengths as a loop shape). Each anode was placed coaxial around the corresponding cathode and the probe, axially movable was passed through the K_2 axis. Axial and radial distributions of light intensity and corresponding optical spectra was obtained using a system of illumination of a entrance slit of a double mono-chromator with high spectral resolution (o.5 cm^{-1}).

The discharges were produced between the cylindrical cathodes K_1, K_2 and the cylindrical anodes A_1, A_2, respectively. The diameters of cylindrical cathodes and anodes were selected so that the cathode – anode distances do not allow to form positive column at the working gas pressure (0.07 to 0.2 Torr argon). and the ends of the two negative glows are placed within the A_1 and A_2 region, respectively. The new plasma formations appears in the

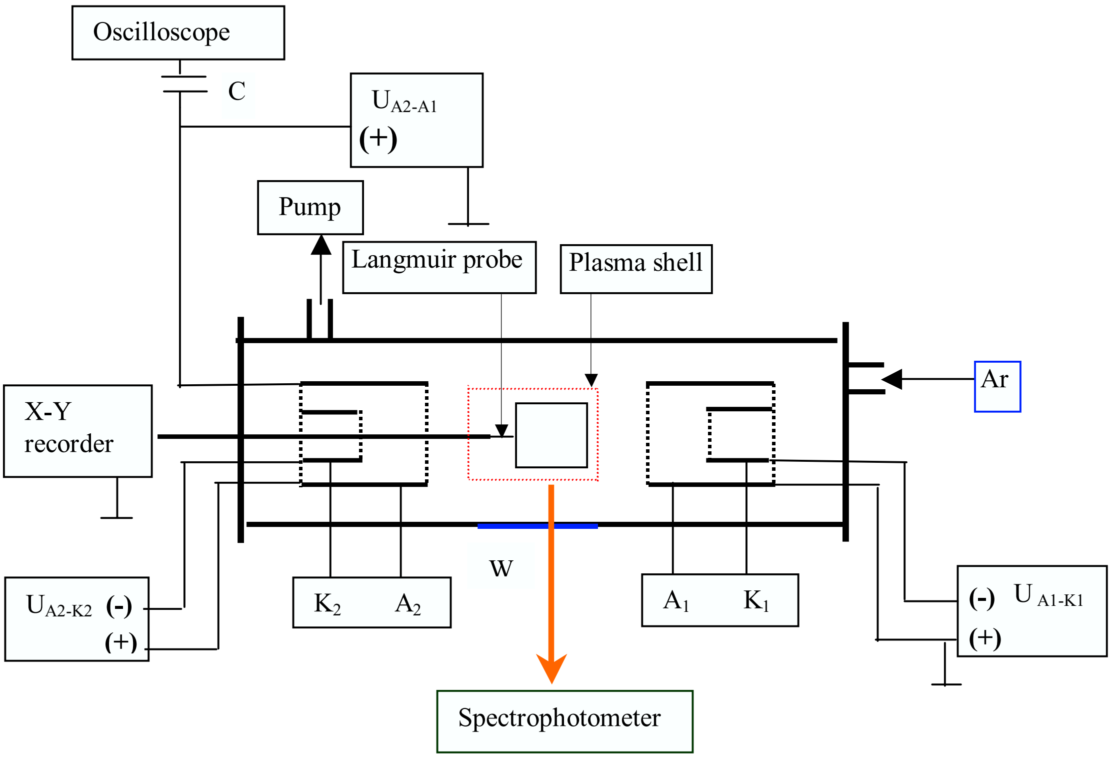

Figure 1 – The experimental set-up

region between A_1 and A_2 (Fig.1), when one of the anode (in our experiment A_2) is positively biased with respect to the other. It has observed that the plasma formations are stable only as long as the potential drop across the plasma formation between the two anodes does not achieve about ionisation potential of the used gases (15.7 V for Ar) (Fig. 1).

In the following the results obtained by electrical probe are presented. Two series of measurements were performed. The first correspond to the axial distribution of the plasma potential. In that case the probe was heated up to thermal emission. The axial distributions of plasma potential are presented in figs 2 to 5 when two or three double layers are formed in the region between the two anodes. In Figure 2 are given the potential structure and profile of the electric field along the axis of the discharge tube, on the spatial domain of existence of two plasma formations, which could be seen separately. The distances were measured from the anode A_2. One can see that the difference of potential on the spatial domain of existence of the two plasma structures is of approximately 31V. The obtained potential structure is typical to a plasma double-layer, i.e. in each plasma formation a double-layer is formed.

In Figure 3 a potential structure and the profile of electric field are given along the discharge tube axis, on the spatial domain of existence of three plasma formations, which could be seen distinctively. The analysis of this potential structure evidences the fact that total potential difference is, also, approximately three times bigger than the ionisation potential of the argon atoms. The form of the potential structure indicates the fact that in every plasma formation a double layer has been formed [3].

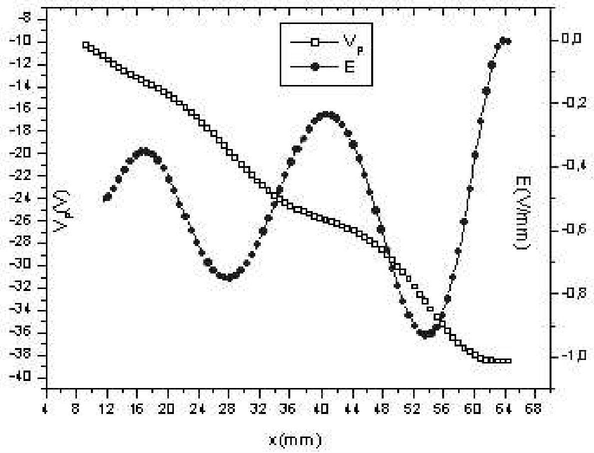

Figure 2 - The profiles of the space potential and electric field across two plasma formations.

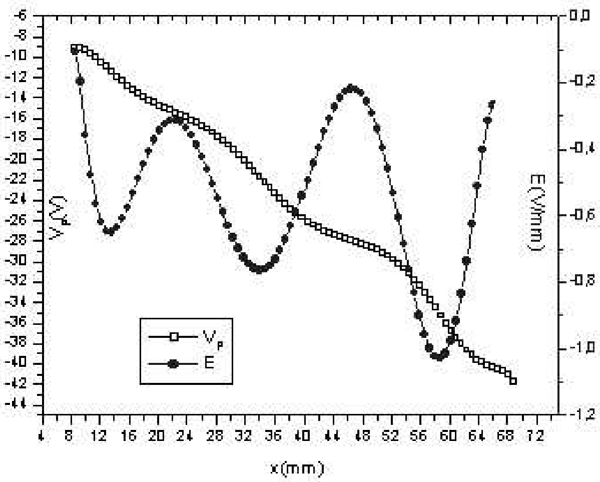

Figure 3 – The profiles of the space potential and electric field across three plasma formations

The electric field structure on the spatial domain of existence of the complex structure of plasma confirms that, in every plasma formation exists a double layer, as well.

In Figures 4 - 5 are given the potential and total charge density (n_t=n_e-n_i), structures on the spatial domain of existence of two formations of plasma, and three formation of plasma, respectively.

One can note that the total density of electric charge structures confirm, as well, the existence of a double layer in each plasma formation.

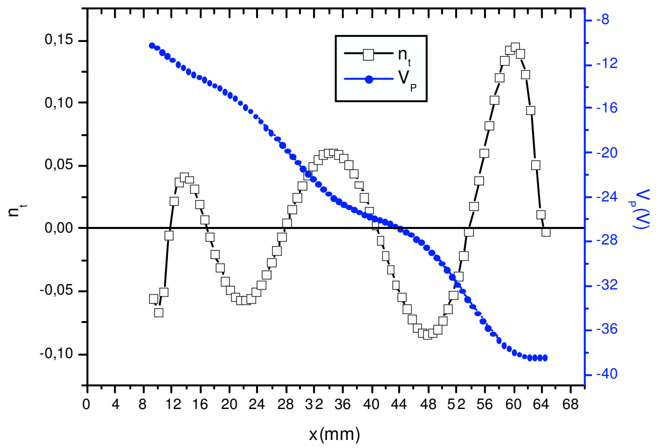

Figure 4 – The potential structure and the profile of charge density along two plasma formations

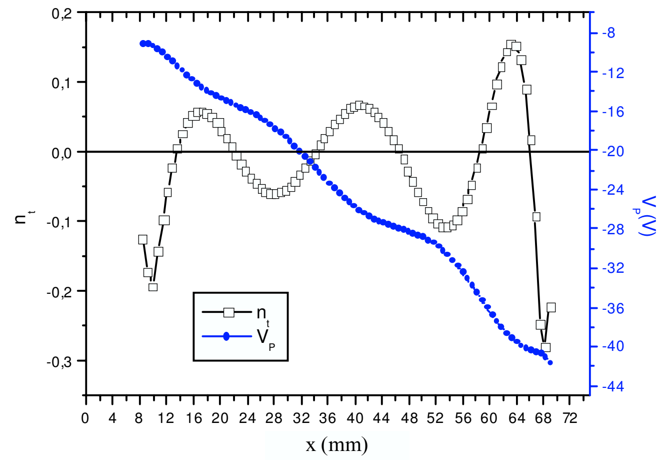

Figure 5 – The potential structure and the profile of charge density along three plasma formations

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