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A SIMPLE HOLLOW CATHODE DEVICE FOR THE STUDY OF THE NEGATIVE GLOW BY THE EFFUSION TECHNIQUE

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The construction of a hollow cathode discharge tube is described. The charge particles, the excited and the ground state atoms and photons present in the negative glow of the hollow cathode discharge can pass through the small orifice (85 μm diameter) into a high vacuum region. The cathode can be displaced against the sampling probe by a shifting mechanism. The preliminary measurements showed a good stability of the plasma in the hollow cathode discharge and reproducibility of the studied parameters.

УСТРОЙСТВО ПРОСТОГО ПОЛОГО КАТОДА ДЛЯ ИССЛЕДОВАНИЯ КАТОДНОГО СВЕЧЕНИЯ ПРИ ПОМОЩИ МЕТОДА ЭФФУЗИИ

В работе описана конструкция разрядной трубки с полым катодом. Заряженные частицы, возбужденные атомы, атомы в основном состоянии и фотоны, присутствующие в катодном свечении тлеющего разряда с полым катодом, проходят через малое отверстие (диаметром в 85 мкм) в областщ высокого вакуума. Катод может быть установлен напротив исследуемого образца при помощи специального механизма. Предварительные измерения показали хорощую устойчивость плазмы в тлеющем разряде с полым катодом и воспроизводимость изучаемых параметров.

I. INTRODUCTION

Elementary processes in a low temperature plasma of the positive column in presence of excited atoms have been studied in [1, 2, 4]. Some details of the experimental method can be found in [3, 4]. The experimental device used in those cases enables us to vary two parameters only:

a) concentration of electrons (by variation of the discharge current),
b) the value of the diffusion coefficient (by variation of the pressure).

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It is known that the hollow cathode discharge is quite different from the glow discharge with plane electrodes [9]. The negative glow of the cylindrical hollow cathode discharge is separated by a sharpe edge from the dark region of the cathode drop of the potential. This fact gives the possibility to study a radial profile of the negative glow.

Generally, the determination of the reaction rate constant for the ion-molecular reaction requires a variation of more than two parameters. For example, it is appropriate to measure the diffusion flux of the ions or metastable atoms not only near the wall of the discharge tube, but also at an arbitrary distance from the wall.

The circumstances mentioned above stimulated various constructions of the discharge tube. We decided to apply a discharge tube with a moving hollow cathode. A similar experimental device was used for the study of the ion-molecular reactions [5]. Of corse, it should be noted that the exciting and ionizing processes in the hollow cathode discharge are different from those, in the positive column.

II. DISCHARGE TUBE

The geometry of the discharge tube was suggested in such a way as to suit the experimental device [4, 6, 7], which was originally built for detecting metastable particles by means of the time-of-flight method.

The discharge tube and its connection with the experimental equipment is schematically shown in Fig. 1. The discharge tube consists of an anode and a cathode section.

The anode section consists of a glass cylinder (28 mm inner diameter, 40 mm length, 1 mm thickness) and of a stainless steel cylindrical hollow anode (11 mm

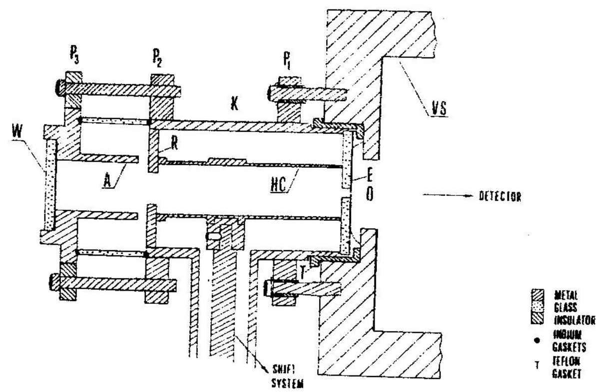

Fig. 1. The discharge tube with a radially displaceable hollow cathode and its connection to the experimental apparatus. A — anode, K — chamber, HC — hollow cathode, O — orifice, P_1, P_2, P_3 — flanges, VS — vacuum system, W — window.

inner diameter, 18 mm length, 1.5 mm thickness). There is a window W in the flange section of the anode for the optical observation of the negative glow. The anode flange P_3 is made of an insulator.

The cathode section consists of a stainless steel cylindrical chamber K (length 45 mm, inner diameter 26 mm, thickness 2 mm) and of a stainless steel hollow cathode (length 40 mm, inner diameter 11 mm, thickness 0.5 mm (see Fig. 1)).

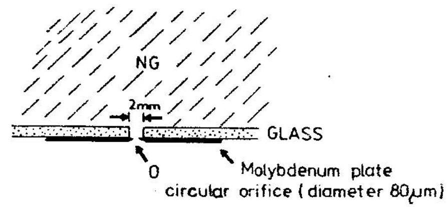

Fig. 2. Section through the sampling probe. NG — negative glow.

The electrode E forms an exit aperture with the orifice 0 in the axis and is insulated by a circular glass disk from the chamber K and the hollow cathode HC. The electrode E is made of a circular molybdenum disk with a 24 mm diameter and 0.1 mm thick. This electrode (in the centre of the glass disk) can be used a small plane probe of 3.14 mm^2 surface. The orifice O was made by a similar technology as in [8]. In the centre of the molybdenum disk a "spherical" cap was made by a needle, which was thereafter ground. The grinding was controlled and the diameter of the orifice was measured by a microscope. Thus an approximately circular orifice was acquired. The glass disk was coupled with the molybdenum electrode by the cement "Torr Seal" and the orifice O was centred against the chamber K. The detail of the electrode E with the effusion orifice is shown in Fig. 2. The chamber K ends on the opposite side by a stainless steel ring R (of a 7 mm inner diameter and 2 mm thick) to ensure the radial displacement of the hollow cathode with respect to the axis of the discharge tube. The chamber is electrically insulated from the experimental device [4, 6, 7] by a supporting Teflon gasket. The vacuum connection between the anode and cathode sections of the discharge tube is made by the application of an indium seal.

III. SHIFT MECHANISM

To determine the radial variation of the effusion flux, the hollow cathode can be displaced radially with respect to the fixed sampling probe. This can be made by means of a micrometer screw. The hollow cathode is fixed to the stainless steel rod of a 165 mm length and a 5 mm diameter with a thread (pitch 0.5 mm, length 70 mm).

The elastic vacuum joint of the micrometer screw with the discharge tube was made by means of stainless steel bellows. Two radial bearings RB were applied to reach the accuracy of the axial motion of the hollow cathode. The micrometer screw was fixed in a special tube. The arrangement of the shift mechanism is shown in Fig. 3.

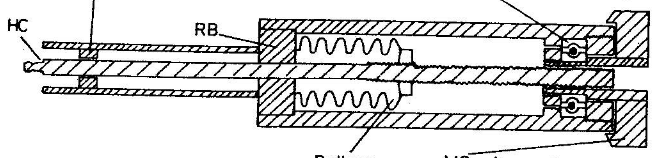

Fig. 3. Shift mechanism. HC — connection to the hollow cathode.

IV. CONCLUSIONS

The preliminary experimental measurements with the help of the hollow cathode discharge have demonstrated the high stability of the plasma in the hollow cathode and a good reproducibility (radial dependence of the ultraviolet radiation, ion retard characteristics).

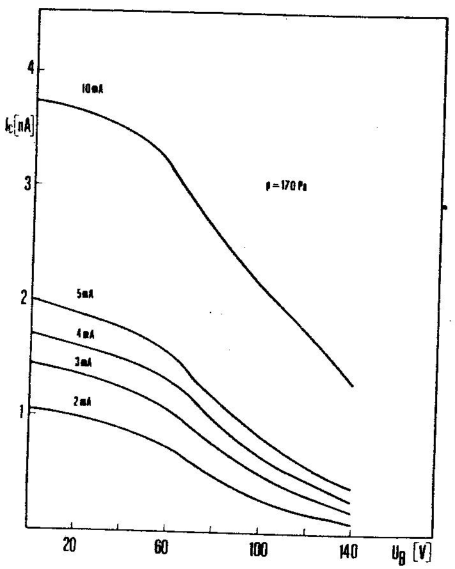

Fig. 4. The retarding potential curves of the positive neon ions effusing from the negative glow of the hollow cathode discharge.

The retarding potential curves corresponding to the energy distribution of positive ions effusing from the hollow cathode are plotted in Fig. 4. Measurements have been made in neon at various pressures and discharge currents. The high energy tail of the ion distribution function observed at low pressures (up to 300 Pa) is richer than in the case of a positive column [10].

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