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Effects of non-uniform dc glow discharge system on argon positive column plasma

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The axial variation of a non-uniform dc glow discharge has been investigated in an untraditional discharge system using isolated computer controlled three couples of fast double Langmuir probe. The plasma parameters in argon plasma have been studied over the pressure ranges from 0.3 to 2.1 Torr. Tube of variable diameters along the axis, 2R, of 4.2 cm (quasi-sphere), and 2.8 cm (short cylinder) was used in the present investigation. The results show that the electron temperature and electric field (density) decreases (increases) as the radius decreases at constant pressure and discharge current. Therefore, a significant tube radius effect has been observed for the all plasma parameters electron temperature, densities, and axial electric filed when we analyse results in term of pR. In addition, the effect of the variable cross-section on the ambipolar diffusion coefficient show distinguished behaviour. As the diffusion length (Λ=R/2.4) increases, the ambipolar diffusion D_a increases, but decreases as the discharge current is increased.

Key words: Fast Langmuir probe, electron temperature, density, non-uniform positive column.

I. Introduction

Dc glow discharge plasmas have been used for plasma applications in the low and intermediate pressure regimes in modern technology, as the fluorescent lamp, Na-vapour lamps, and as a source of radiation like gas laser. Our system, which consist of three regions as shown in Fig. 1, the positive column is constructed with a variable shape of discharge tube (internal tube).The first and the third region are like a sphere with the same radius (2.1 cm), but the middle part is like a very short cylindrical tube with a radius (1.4 cm).Hence, the plasma parameters; electron temperature, electron density, and axial electric field will be changed from one region to another under the same conditions. The probe technique is an important one because it has an advantage over all diagnostic techniques: it can make local measurements. Almost all other techniques, such as spectroscopy or microwave propagation, give information averaged over a large volume of plasma [1]. To measure plasma parameters for all regions, especially ion currents, with good accuracy and without contamination problems, it would be appropriate if the data collection can be done in a few seconds. The fast computerized three couples of double probe system (TCDP) have been developed.

II. Experimental apparatus

The experiments are performed using two-stage vacuum pump (mechanical and oil diffusion) to evacuate the whole system down to 10^{-4} Torr. Argon is used as plasma forming gas during measurement to avoid possible negative effect of complex chemical reaction when a non-inert gas is applied. The discharge tubes which are made of Pyrex glass as shown in Fig. 1 consists of external uniform cylindrical tube (length 30 cm, inner diameter 5.6 cm) and internal non uniform tube(length 30 cm, inner diameter for regions near the cathode and anode are 4.2 cm, but in the middle is 2.8 cm). The construction of the fast double probe system used in this investigation is described in ref.[2].

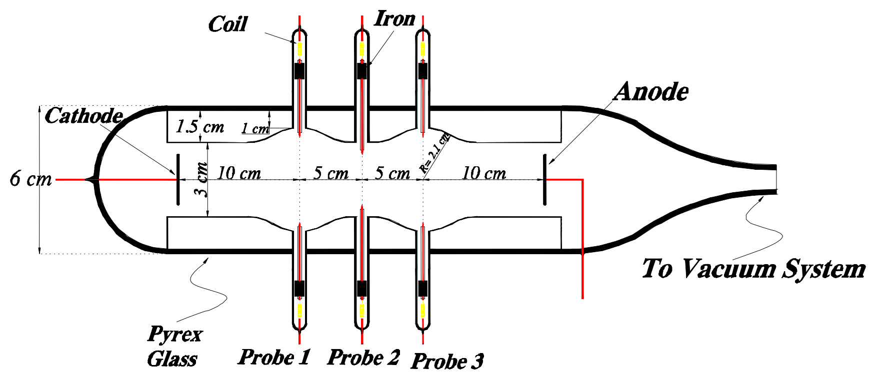

Fig.(1) Schematic diagram of experimental apparatus.

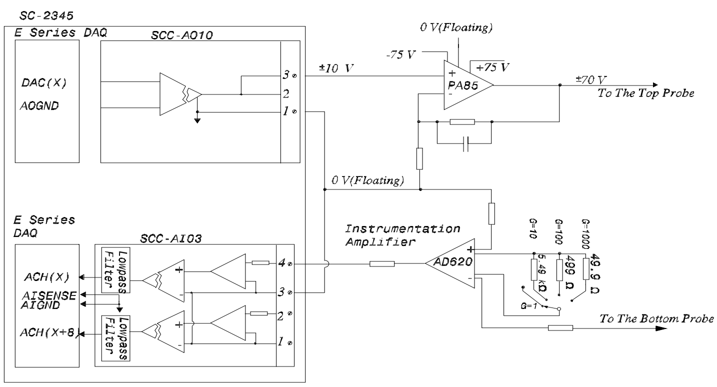

Fig. 2- Schematic diagrams of the double probe diagnostic system.

III. Result and discussion

The variation of the electron temperature T_e and density n_e in argon gas for deferent values of the discharge current I_d as a function of (pR); p is the gas pressure in Torr, and R is the tube radius (R1 and R3 are equal to 2.1 cm, and R2 is 1.4 cm) is shown in Fig. 3-4.

The common trends of the curves (for all probes at the centre of discharge tube) are that the electron temperature tends to increase steeply as the product pR decreases. Since, as the pressure increases the mean free path and the energy acquired by the electrons decreases. This is due to the reducing of the ionization process [3, 4–6]. Furthermore, for probe1, we found that the electron temperature T_{e1} decreases and density increases as the discharge current increases. The collision loss factor is increased with the increase of the discharge current because the cumulative ionization effect brings the increase of the inelastic collision loss by electrons with lower energy as shown by Dote and Kaneda[7].

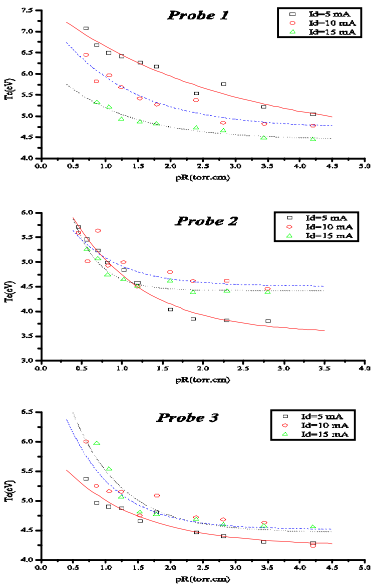

Fig. 3-Electron temperature as a function of pR at different discharge currents (at fixed radial distance (1.7 cm), and (1 cm) for probes 1, 3 and 2 respectively).

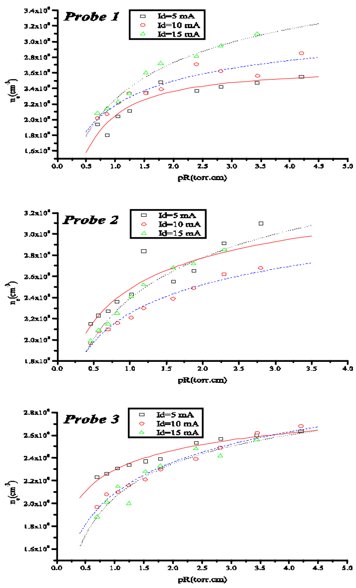

Fig. 4-Electron density as a function of pR at the same conditions as Fig. 3.

However, for probe3, T_{e3} increases with discharge current. Since, as we approach, the anode region of a glow discharge represents a typical interaction region for low-pressure plasma and a conducting surface which absorbs electrons. More precisely, the transition from the axially homogeneous positive column of the charges to the equipotential anode surface takes place in this region. For probe2, the electron temperature T_{e2} decreases with increasing electron density as the discharge current increased, because of the higher electron density, electron-electron collisions, are more important [8, 9].

The non-uniform positive column argon dc glow discharge plasma has been investigated experimentally. The results show that: The electron temperature decreases, and electron density increases with pR at low discharge currents. For the relation between the electron densities with the discharge current, there is an unexpected result at the small radius region. In general, the n_e must increase with I_d but it is decreased here. However, the effect of variable radii system leads to give unexpected results. The small radius caused to increase the density and decrease of the electron temperature and electric field. Therefore, the uniformity of the positive column has been changed, with approximate electrical neutrality.

References

[1] F. F. Chen, Plasma Diagnostic Techniques, Academic Press INC., New York, (1965).

[2] D. Akbar and S. Bilikmen Chinese Phys. Letters 23, 1234, (2006).

[3] G. Alferd, Cold Plasma in Material Fabrication: from fundamentals to applications, IEEE Press , New York, (2002).

[4] A. G. Mathewson, A. Grillot, and S. Hazeltine, Vacuum, 31, 337, (1981).

[5] T. M. Desai, S. V. Gorwale, and Shukla, Vacuum, 46, 223, (1995)

[6] T. Kaneda, J. Phys. D: Appl. Phys. 12, 61, (1979).

[7] T. Dote and T. Kaneda, Jap. J. Appl. Phys., 15, 1399, (1976).

[8] D. Uhrlandt, J. Phys. D: Appl. Phys, 35, 2159, (2002).

[9] B. Hartgers, J. Dijk, G. Janssen, and J. Mullen, Eindhoven University of Technology, Part of research programme.