

Study the Characteristics of Subnormal Glow Discharge in Presence of Transverse Magnetic Field in Air

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ABSTRACT

In Subnormal Glow region current-voltage characteristic has a negative slope which is also pressure dependent. The voltage decreases exponentially with the discharge current. This characteristic property has been studied [1]. Our aim of the present work is to specify this Subnormal Glow region by an analytical expression and to extend it in presence of transverse magnetic field. Therefore the current- voltage characteristics have been studied in air and an analytical expression have been introduced which includes a dimensional constant, m_p . The m_p - values have been determined in presence of transverse magnetic field (H) : 0, 20, 40 and 60 Gauss for the constant pressures 0.4, 0.45, 0.5 and 0.6 Torr. From our study it is established that the analytical expression is applicable in presence of transverse magnetic field.

Keywords: Subnormal glow, analytical expression, dimensional constant.

1. Introduction

When the appropriate value of the potential difference is maintained between the two electrodes separated by a certain distance in a discharge tube containing air at atmospheric pressure, it is found that the gas in discharge tube between two electrodes remain in its original state as particularly perfect insulator. Now if the potential difference between the two electrodes is increased and the air pressure inside the discharge tube is decreased to lower the value then first a spark is produced. If the potential difference is increased further the insulation breaks down and the usual narrow electric sparks between the electrodes. If the pressure inside the tube is sufficiently low and the voltage applied between the two electrodes is sufficiently high then spark becomes broader. The aim of the present investigation is to study the variation of discharge current with tube voltage in Subnormal Glow

region in Air in presence of transverse magnetic field at different constant pressures and to specify this region by an analytical expression. The discharge with positive space charge which are transitional between Townsend discharges and normal glow discharges, known as Subnormal Glow discharges are found to be striated in few inert gases and Hg – vapour [2]. Few other authors [3, 4] have reported that current in subnormal glow region fluctuates due to the motion of space charge. In Subnormal glow region the current-voltage characteristic has a negative slope [1, 5].

2. Experimental Procedure

The experimental set-up for this work has been shown in Fig. 1.

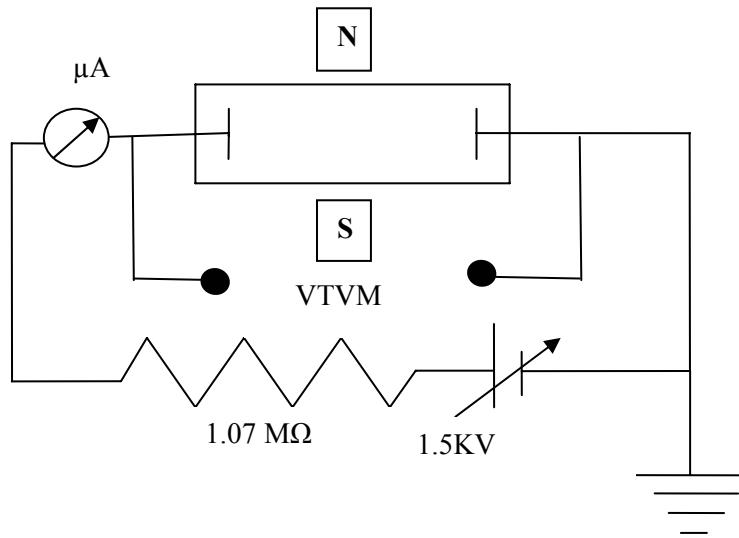


Fig. 1: Experimental Set-up

The discharge tube, a cylindrical pyrex glass tube of length 6 cm and inner diameter 4.8 cm, is fitted with two plane parallel copper electrodes of diameter 4 cm, at a separation 1.8 cm. The tube is thoroughly cleaned and dried. The discharge tube was excited by a dc voltage from the high voltage unit which could supply up to 1.5 KV with insignificant ripples. The ballast resistor of $1.0 \text{ M}\Omega$ limits the discharge current and keeps the high voltage unit within its current capacity. A current meter was inserted in series with discharge tube to record the average current. A high input impedance VTVM is connected across the discharge tube to record potential difference. A micro-leak needle valve is connected with the discharge tube to monitor the gas pressure within the tube. The tube was excited at different pressures and transverse magnetic field and the current- voltage readings were recorded in the Subnormal glow region.

3. Results and Discussion

The variation of potential difference (V) across two electrodes with average tube current (I) is represented by the equation

$$V = V_0 \exp(-m_p I)$$

Where, m_p = dimensional constant

and V_0 = potential difference at zero discharge current.

The value m_p has been calculated by a statistical method :

$$V = V_0 \exp(-m_p I)$$

$$\ln V = \ln V_0 - m_p I$$

$$\text{and } S = \sum [\ln V - \ln V_0 + m_p I]^2$$

Therefore for the minimum value of S,

$$\frac{ds}{dm_p} = 2 \sum I [\ln V - \ln V_0 + m_p I] = 0$$

$$\text{Or, } \sum I \ln V = \ln V_0 \sum I - m_p \sum I^2 \quad \text{Or, } m_p = [\ln V_0 \sum I - \sum I \ln V] / \sum I^2$$

The values of V, potential difference across the electrodes after breakdown and their corresponding discharge currents(I) have been recorded for different pressures (P), namely, 0.4, 0.45, 0.5, 0.6 Torr for without and with different transverse magnetic fields(H) 0 Gauss, 20 Gauss, 40 Gauss, and 60 Gauss and these are plotted in Fig.2, Fig.3, Fig.4 and Fig.5 respectively.

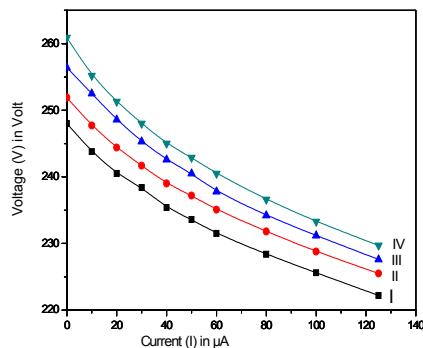


Fig.2. Current –Voltage characteristics

$H = 0$ Gauss

Pressures: I : 0.4 Torr, II: 0.45 Torr; III: 0.5 Torr, IV: 0.6 Torr.

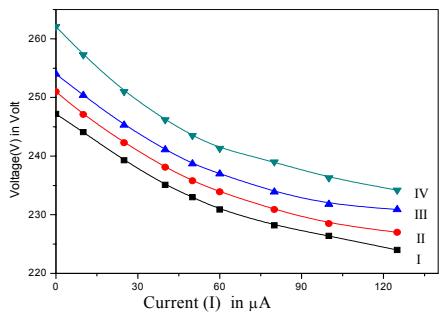


Fig.3. Current –Voltage characteristics

$H = 20$ Gauss

Pressures: I : 0.4 Torr, II: 0.45 Torr; III: 0.5 Torr, IV: 0.6 Torr.

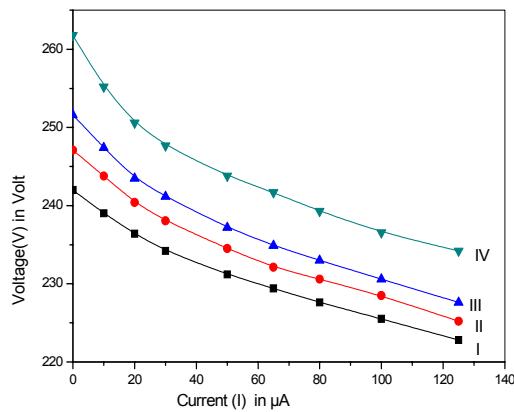


Fig.4. Current -Voltage characteristics

$H = 40$ Gauss

Pressures: I : 0.4 Torr, II: 0.45 Torr; III: 0.5 Torr, IV: 0.6 Torr.

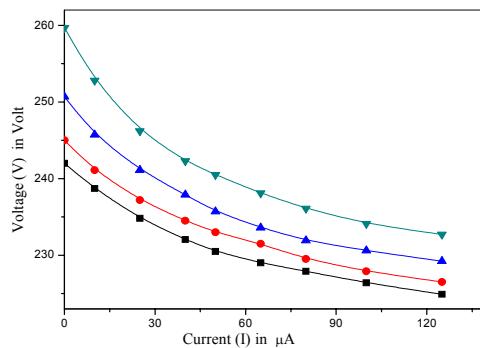


Fig.5. Current –Voltage characteristics

$H = 60$ Gauss

Pressures: I : 0.4 Torr, II: 0.45 Torr; III: 0.5 Torr, IV: 0.6 Torr.

The values of m_p are calculated and entered in the tabular form.

TABLE-1 Variation of m_p -values with magnetic field and pressure

Magnetic field(H) in Gauss	Value of m_p for Pressure=0.4 Torr	Value of m_p for Pressure=0.45T orr	Value of m_p for Pressure=0.5 Torr	Value of m_p for Pressure=0.6 Torr
0	907.2	888.28	989.28	1077.44
20	825.1	779.06	908.72	935.54
40	731.03	715.99	830.63	878.6
60	622.53	615.19	774.71	708.12

4. Conclusion

The current–voltage characteristics are studied and an analytical expression is introduced to describe the Subnormal glow region. This is extended in presence of

the transverse magnetic field. The value of the dimensional constant (m_p) is determined and it is found that m_p decreases with the increases of transverse magnetic field. From this investigation it is found that there is a future scope of study of the same work for molecular and inert gases with the variation of magnetic field and pressure.

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