Journal of Physical Sciences, Vol. 21, 2016, 139-144
ISSN: 2350-0352 (print), www.vidyasagar.ac.in/journal
Published on 24 December 2016

Characteristics of Subnormal Glow Discharge in Longitudinal Magnetic Field in Air

S. S. Pradhan

Department of Physics, Midnapore College (Autonomous), Midnapore
Paschim Medinipur-721101, India. e-mail: sitangshu.pradhan@gmail.com

Received 4 September 2016; accepted 13 November2016

ABSTRACT

The current-voltage characteristic of subnormal glow discharge has a negative slope [1]. The voltage decreases exponentially with the discharge current. This property has been studied and an analytical expression has been introduced to represent the subnormal glow region [2]. This expression contains a dimensional constant m_p. In transverse magnetic field the same work has been studied and the subnormal glow discharge has been explained satisfactorily using the same analytical expression [3]. The aim of the present work is to study the current-voltage characteristic in longitudinal magnetic field and to explain the subnormal glow discharge with the introduced dimensional constant m_p. It is observed that the subnormal glow discharge is explained satisfactorily in longitudinal magnetic field as well using the analytical expression containing dimensional constant m_p.

Keywords: Subnormal glow, analytical expression, dimensional constant.

1. Introduction

With an appreciable potential difference maintained between two electrodes of the discharge tube containing air at atmospheric pressure, no discharge occurs. As the pressure is decreased, at first a spark is found. This spark becomes broader as the tube pressure decreases more. In this procedure the gas breaks down. The aim of the present investigation is to study the variation of discharge current with tube voltage in subnormal glow region in presence of longitudinal magnetic field in air at different fixed pressures to specify this region by an analytical expression. The discharge with positive space charge between Townsend discharge and normal glow discharge is known as subnormal glow which is found to be striated in few inert gases and Hg-vapour [4]. Few other authors [5,6] have reported that the current fluctuations are found in subnormal glow region due to the motion of space charges. The experimental set-up for the study of the present work is shown in Fig. 1.

2. Experimental arrangement

The experimental set-up for the study of the present work is shown in Figure 1. The discharge tube used is made of pyrex glass and it is of length 6 cm, inner diameter 4.8 cm, fitted with two plane parallel circular copper electrodes of diameter 4 cm separated by a distance 1.8 cm. The tube is thoroughly cleaned and dried. The discharge tube was exited by a dc voltage from the high voltage unit which could supply up to 1.5 KV with insignificant ripples.

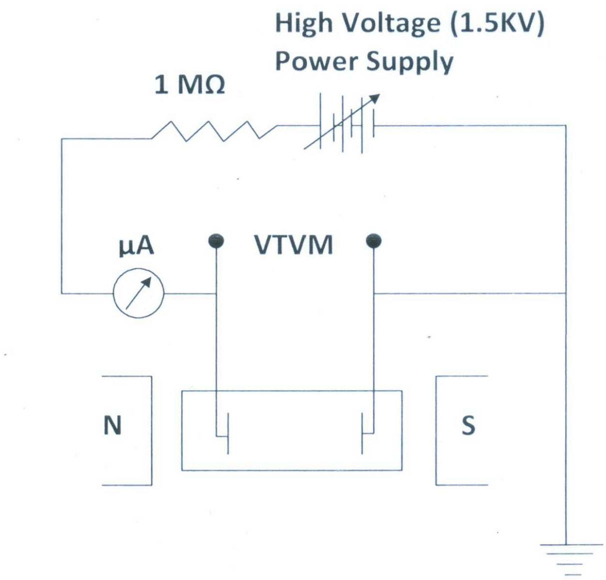

Figure 1. Experimental Set-up

The ballast resistor of 1.0 MΩ limits the discharge current and keeps the high voltage unit within its current capacity. A current meter was connected in series with discharge tube to record the discharge 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 control the gas pressure within the tube. The magnetic field was produced by an electromagnet. The tube was excited at different pressures and longitudinal 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 discharge current (I) is represented by an analytical expression,

$$V = V_0 \, Exp\,(-m_p I),$$

where, m_p = dimensional constant

and V_0 = potential difference at zero discharge current.

The value m_p has been calculated by the following statistical method:

$$V = V_0 \, Exp\,(-m_p I)$$

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

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

Therefore for the minimum value of S,

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

Or, $\sum I \ln V = \ln V_0 \sum I - m_p \sum I^2$ 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 longitudinal magnetic fields(H) 0 Gauss, 375 Gauss, 750 Gauss, and 1125 Gauss and these are plotted in Fig.2, Fig.3, Fig4 & Fig.5 respectively.

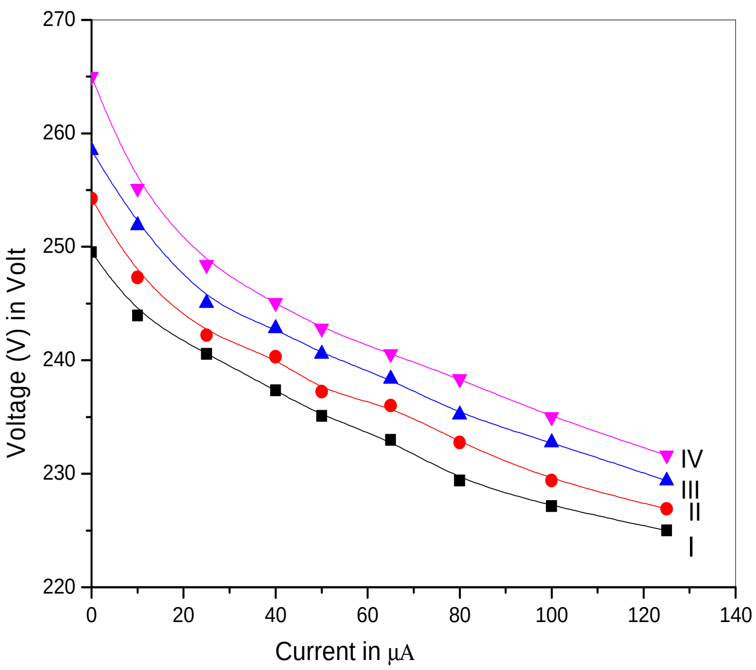

Figure 2. Current-Voltage Characteristics. H= 0 Gauss,   Pressures: I:0.4 torr, II:0.45 torr, III:0.5torr, IV:0.6 torr

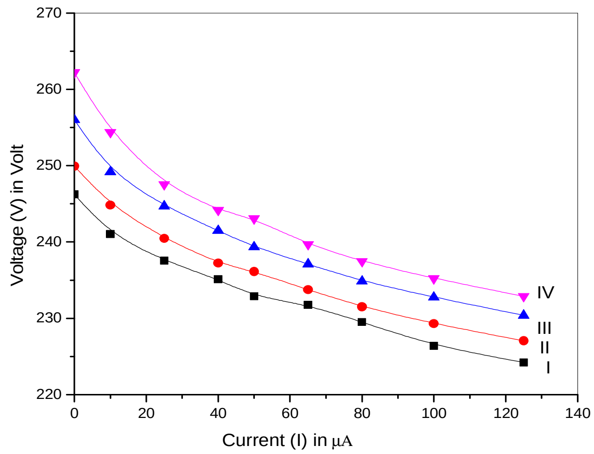

Figure 3. Current - Voltage Characteristics. H=375 Gauss, Pressures: I:0.4 torr, II:0.45 torr, III:0.5torr, IV:0.6 torr

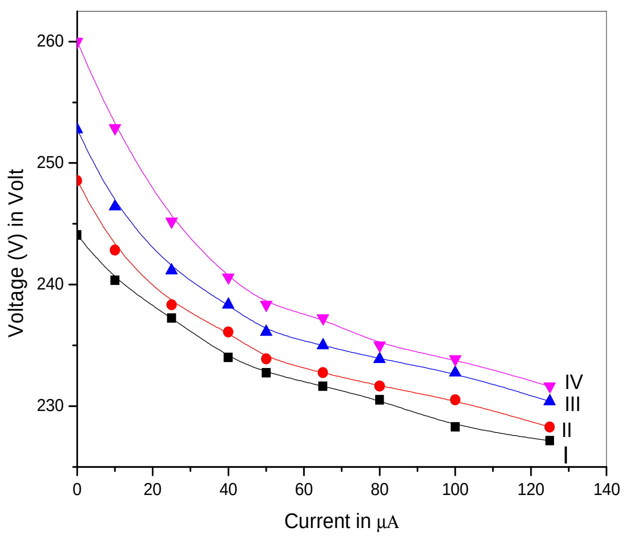

Figure 4. Current - Voltage Characteristics . H=750 Gauss, Pressures: I:0.4 torr, II:0.45 torr, III:0.5torr, IV:0.6 torr

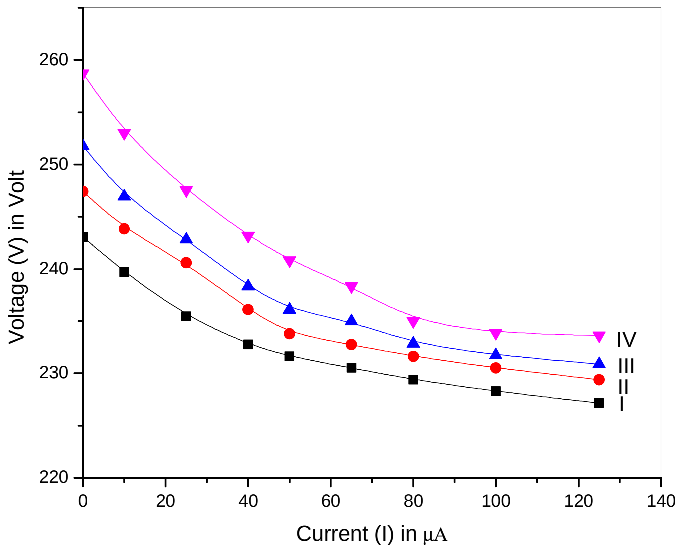

Figure 5. Current -Voltage Characteristics. H=1125 Gauss, Pressures: I:0.4 torr, II:0.45 torr, III:0.5torr, IV:0.6 torr

The values of m_p are calculated from Figure-2, Figure-3, Figure-4 and Figure-5 and entered in Table 1.

Table 1. Variation of m_p-values with magnetic field and pressure

Magnetic field(H) in Gauss	Value of m_p for Pressure: 0.4torr	Value of m_p for Pressure: 0.45torr	Value of m_p for Pressure: 0.5torr	Value of m_p for Pressure: 0.6torr
0G	965.283	1062.386	1117.78	1291.096
375G	862.465	906.449	1015.013	1164.353
750 G	695.889	838.217	924.953	1155.349
1125 G	678.836	762.640	884.745	1053.624

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 longitudinal magnetic field. The value of the dimensional constant (m_p) is determined and it is found that m_p decreases with the increase in 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.

REFERENCES

1. M.J.Druyvestyn and F.M.Penning, The mechanism of electrical discharges in gases of low pressure, *Rev. Mod. Phys.,* 12 (1940) 87.
2. D.C.Jana and S.S.Pradhan, Characterization of current, voltage, power and nature of the current pulses on pressure in a subnormal glow discharge region in air. *Indian Journal of Pure & Applied Physics*, 38 (2000) 766-770.
3. S.S.Pradhan and D.C.Jana, Study the characteristics of subnormal glow in presence of transverse magnetic field in air, *Journal of Physical Sciences*, 14 (2010) 241-246.
4. K.G.Emeleus, Low-current striated townsend and transitional discharges. *Int. Journal of Electronics*, 39 (1975) 177.
5. Melvin, A.Harrison and R.Geballe, simultaneous measurement of ionization and attachment coefficients. *Phys. Rev.,* 91, (1953) 1.
6. A.M.Pillon, Intensities of X-Rays and γ Rays in Am 241 Alpha Decay. *Physical Review*, 107 (1957) 254.