GENERATION OF HOMOGENEOUS GLOW DISCHARGE USING A COMBINATION OF FINE WIRE MESH AND PERFORATED ALUMINIUM ELECTRODE

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Special for:

My beloved parents

And my beloved husband

Dedicated, in thankful appreciation for support, encouragement and understandings to my supervisor

Assoc. Prof. Dr Zolkafle bin Buntat

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ABSTRACT

Nowadays, a gas discharge plasma applications has rapidly extended due to the greatest chemical freedom offered by the non-equilibrium aspects of the plasma. Among the applications of gas discharge plasma are surface treatment, air pollution control, lasers, lighting, plasma displays, ozone generation and biomedical applications. The most commonly used in plasma industry is the glow discharge plasma. It is known to be generated under high vacuum condition. At low pressure glow discharge plasma, the producing of surfaces and thin films are more effectives and good quality. But, this technique gives disadvantages due to the large cost to maintain at low pressure condition. However, there were many researches that have been done to produce glow discharge at atmospheric pressure. This glow discharge can be stabilize at atmospheric pressure if three simple requirements are fulfilled: (i) use of source frequency of over 1 kHz, (ii) insertion of a dielectric plates between the two metal electrodes, (iii) use of helium dilution gas. Used of helium gas is impractical due to its high cost. In order to generate glow discharge at atmospheric pressure in any gases, it was found that fine wire mesh and perforated aluminium can maintain a stable glow discharges. This thesis focus on the production of homogeneous glow discharge by using a combination of fine wire mesh and perforated aluminium as electrodes. A study was also made to determine the effect of a frequency and gap spacing on the stability of glow discharge.

ABSTRAK

Pada masa kini, penggunaan penyahcasan gas plasma telah berkembang pesat disebabkan aspek bebas kimia yang terdapat pada plasma tidak-seimbang ini. Antara penggunaan penyahcasan gas plasma adalah rawatan permukaan, kawalan pencemaran udara, lazer, pencahayaan, tatapan plasma, penghasilan ozon dan penggunaan perubatan. Kebanyakan plasma yang digunakan dalam industri plasma adalah penyahcasan plasma pijar. Ia dikenali untuk dihasilkan dibawah keadaan vakum yang tinggi. Pada tekanan yang rendah, penghasilan permukaan dan filem nipis adalah lebih efektif dan mendapat kualiti yang bagus. Tetapi, teknik ini tidak memberi faedah kerana ia memerlukan kos yang tinggi untuk kekal pada keadaan tekanan yang rendah. Walaubagaimanapun, banyak kajian telah dijalankan untuk menghasilkan plasma gas ini pada tekanan atmosfera. Penyahcasan gas ini boleh kekal dalam keadaan stabil sekiranya tiga syarat-syarat ini dipenuhi: (i) penggunaan sumber frekuensi melebihi 1 kHz, (ii) penggunaan lapisan dielectric diantara elektrod, (iii) menggunakan gas helium. Penggunaan gas helium tidak praktikal kerana kosnya yang tinggi. Untuk menghasilkan penyahcasan gas ini pada tekanan atmosfera dalam apa jua gas, ia telah dijumpai bahawa penggunaan wayar ‘mesh’ and aluminium yang berlubang boleh mengekalkan kestabilan penyahcasan gas ini. Tesis ini fokus kepada penghasilan penyahcasan gas yang seragam menggunakan gabungan wayar ‘mesh’ dan aluminium yang berlubang sebagai elektrod. Kajian juga dibuat utnuk menentukan kesan frekuensi dan jarak elektrod pada kestabilan penyahcasan gas ini.

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LIST OF ABBREVIATIONS

Hz	-	Hertz
ICP	-	Inductive Coupled Plasma
RF	-	Radio Frequency
DC	-	Direct current
CO2	-	Carbon dioxide
H2	-	Hydrogen
N2	-	Nitrogen
He	-	Helium
Ar	-	Argon
DBD	-	Dielectric Barrier Discharge
APGD	-	Atmospoheric Pressure Glow Discharge
SED	-	Silent electric discharge
Al_2O_2	-	Alumina Ceramic
CRT	-	Cathode Ray Tube
PDP	-	Plasma display panel
PALC	-	Plasma adressed liquid crystal
LC	-	Liquid crystal
PP	-	Polypropylene

LIST OF SYMBOLS

E	-	Electric field
V	-	Voltage
d	-	distance
i_0	-	low initial current
μ_e	-	electron mobility
α	-	Townsend coefficient
λ	-	secondary emission coefficient
cm	-	centimetre
A	-	Ampere
kW	-	kilowatt
x	-	thickness of dielectric
p	-	power dissipated
f	-	frequency
C_D	-	dielectric capacitance

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CHAPTER 1

INTRODUCTION

1.1 Research background

In recent years, a gas discharge plasma applications has rapidly extended due to the great chemical freedom offered by the non-equilibrium aspects of the plasma. Gas discharge plasma present considerable interest for a wide range of applications such as surface treatment, air pollution control, lasers, lighting, plasma displays, ozone generation and biomedical applications [1].

The most commonly used in plasma spechtrochemist is the glow discharge plasma. Glow discharge plasmas are known to be generated under a so-called high vacuum condition. The producing of surfaces and thin films are more effectives and relatively good quality under low pressure glow discharge plasma technique. However, this technique gives disadvantages in its production process since it is necessary to maintain at low pressure condition and therefore, a large amount of cost is necessary to keep the system air-tight.

In general, the glow plasma is thought to be stable only in a low pressure discharge. This is because the discharge concentrates on one point a pressure of about 100 Torr. When the pressure is rising, the discharge shifts to sparks and arc at about atmospheric pressure and thus, making it impossible to uniformly process an object [2]. But, glow discharge is possible to stabilize at atmospheric pressure if three simple requirements are fulfilled: (i) use of source frequency of over 1 kHz, (ii) insertion of a dielectric plate (or plates) between the two metal electrodes, (iii) use of helium dilution gas [3,4]. Used of helium as dilution gas is able to produce a stable and homogeneous glow discharge at atmospheric pressure is due to its low breakdown stress and thus, makes it easy to produce the small avalanches that are required [5]. On the other hand, the use of helium as dilution gas is impractical due to its high cost. It is increases in interesting of researchers to use other low-cost of gases. In this field, a new technique of stabilizing the homogeneous glow discharge at atmospheric pressure in any gases by a 50 Hz source is proposed [6]. This method used a fine wire mesh as a discharge electrodes and it is found that fine mesh electrodes can maintain a stable glow discharges in any type of gases. In [7], it has been confirmed that wire mesh is very important in increasing the possibility of the existence of glow discharge plasma at atmospheric pressure. They also suggested that the mesh could influence the discharge by its electrical resistance which is higher than metallic electrodes. Besides fine mesh wire, perforated aluminium sheet electrode is introduced for comparison with the well-known fine stainless steel wire mesh. From this work, it was found that perforated material electrode can produce a homogeneous glow discharge as an alternative of the well established fine steel wire mesh [8].

This thesis focuses on the production of homogeneous glow discharge by using a combination of fine wire mesh and perforated aluminium as electrodes. A study of the relevant literature has confirmed that uniform and stable glow discharge also dependent on the material of electrodes used. Uniformly distribution of the electric field strength throughout the electrode surface may be due to the shape and size of the holes, as well as the material used. However, the reason why glow discharge has different stability when different configuration of material used as electrodes is not clear. For this reason, further study on the effect of material used as electrodes is proposed in this project. Combination of these two materials as electrodes is introduced instead of using these two materials as electrodes separately. A study was also made to determine the effect of a frequency and pulse of the input voltage on the stability of glow discharge.

1.1 Problem Statement

Nowadays, the use of plasma which is generated by discharge has widely applications including surface treatment of semiconductor, formation of thin films, ozone generation, biomedical applications etc. Glow discharge is well-known generated under low-pressure condition but it is costly in order to maintain at low-pressure state. Thus, many researchers have worked out to introduce techniques which can generate glow discharge plasma under atmospheric pressure to replace the conventional low pressure glow discharge method. In order to achieve a stability of glow discharge at atmospheric pressure, it depends on the feed gas, the dielectric barrier material, the discharge electrode structure, the pulsed supply frequency, the gap spacing and the humidity of the gas.

Homogeneous glow discharges can be established at atmospheric pressure by using special kinds of electrode material and configuration. In [6], it has shown that with wire mesh as electrodes behind the dielectric barriers homogeneous discharge can be obtained with any gas at atmospheric pressure. This result also has been confirmed by [7], and it has also been found that fine mesh electrodes produce a more stable glow than coarse mesh electrodes.

Furthermore, for comparison with well established fine wire mesh, perforated aluminium electrode was introduced into reaction chamber [8]. It has been found that perforated aluminium with small holes can generate a homogeneous glow discharge compared to fine wire mesh electrode. Initially, perforated aluminium is expected to produce higher electric field strength than fine wire mesh due to its sharp edges holes. Higher electric field strength can cause ionization that will produce more micro-discharges near the electrodes. It further, will give a discharge that fills up the whole volume of the discharge chamber.

Nevertheless, simulation results on the observation of electric field strength between these two materials showed that wire mesh configuration produced higher electric field strength than perforated aluminium. This result proved that electric field strength does not influence the stability of the glow discharge. Thus, it makes the reason why the glow discharge produced by the configuration with perforated aluminium has better stability than the wire mesh is unclear.

In this present study, production of glow discharge by using a combination of fine wire mesh and perforated aluminium as electrodes will be investigated. In addition, the effect of frequency and pulse supply on the stability of glow discharge also will be studied.

1.2 Objectives

The aim of this project is to study on the effect of new configuration and combination of two materials on the generation of glow discharge. This aims will be met through these objectives:

1. To develop glow discharge chamber which having different configuration consist of a combination of fine wire mesh and perforated aluminum electrodes.
2. To develop input driver of pulsed voltage that will be used as a supply for the chamber.
3. To conduct an experiment to study the effect of each discharge configuration on glow discharge characteristics.
4. To study the effect of glow discharge stabilization when frequency and gap distance of electrode is varied.

1.4 Scope of work

The scope of this project in generating a stable glow discharge is stated as follows:

1. Several glow discharge chamber with different configuration of a combination of fine wire mesh and perforated aluminum electrodes will be developed.

2. Input driver of pulsed voltage will be developed.
3. An experimental work will be conducted to study the effect of each discharge configuration on glow discharge characteristics.
4. The glow discharge generated will then be detected and then will be analyzed in order to identify the homogeneity of the discharge.

1.5 Methodology of Project

This project is done in sequence in order to ensure that the project will be done in a specific time. The flow of this project is as shown below:

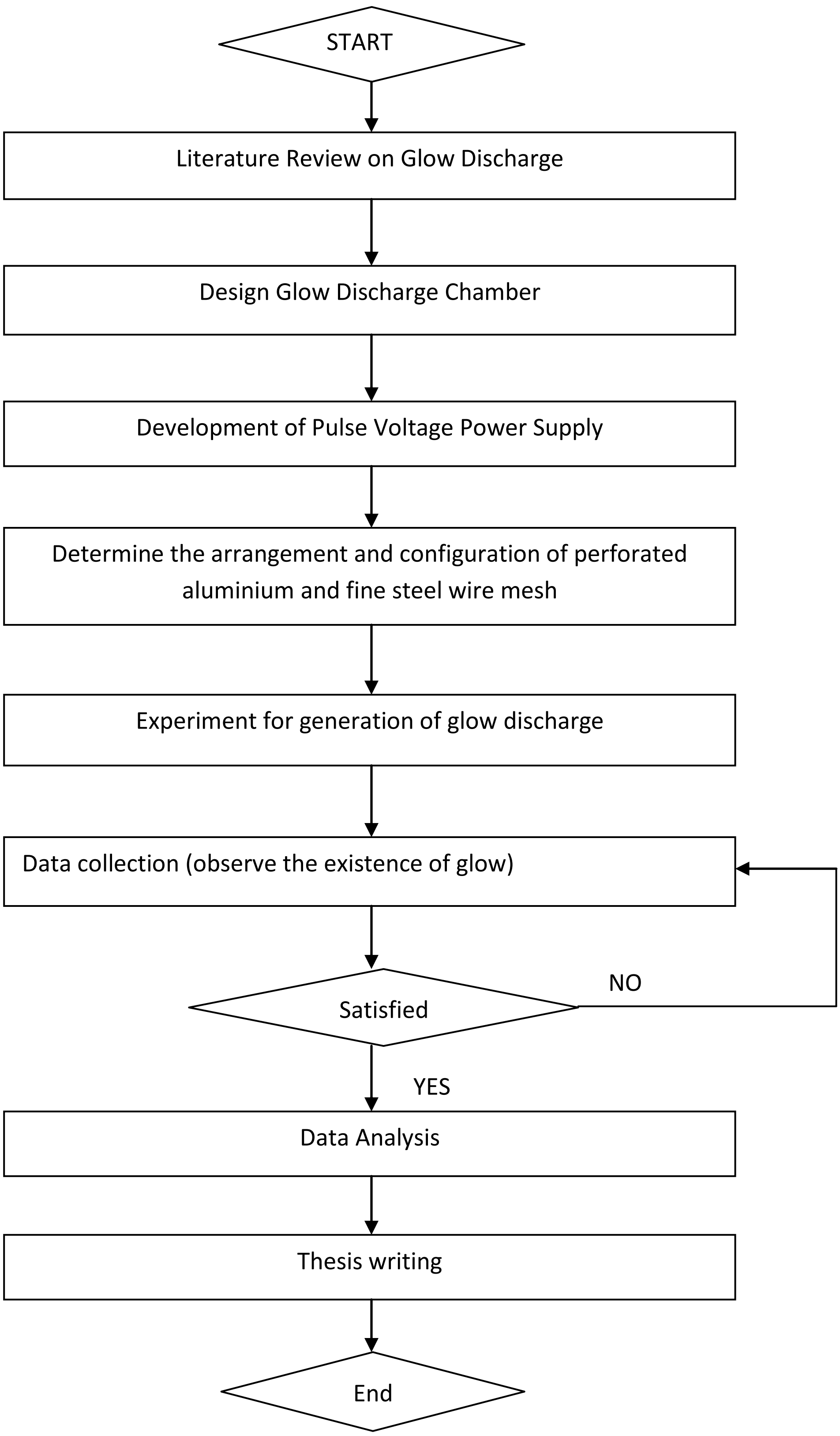

Figure 1.1 Flow chart of the project

1.6 Thesis Outline

This thesis is divided into five chapters. Each chapter is briefly described as below:

Chapter 1 is the introduction of this project including brief description on background of study, problem statements, objectives, scopes of work and methodology of this project.

In chapter 2, the literature review on glow discharge is being discussed. Several sources of information consist of research papers, journal and reference books that help the implementation of this project are further elaborated.

In chapter 3, the methodologies and apparatus of the project are being discussed. It consists of two main parts, the high frequency power supply and the glow discharge chamber.

The results and analysis of the project are discussed in chapter 4. Two types of results are covered in this chapter which are influences of frequency and influences of gap spacing.

Chapter 5 is the conclusion and future development of this project. Some suggestions are provided in this chapter for further improvement of this project.

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