

# Plasma- An Environment Friendly Technology

Rahul Ohlan

Dept. of electronics and Communication Engineering, Deenbandhu Chhotu Ram University of Science and technology, Murthal, Sonapat

DOI: <https://doi.org/10.26438/ijcse/v7i2.870873> | Available online at: [www.ijcseonline.org](http://www.ijcseonline.org)

Accepted: 22/Feb/2019, Published: 28/Feb/2019

**Abstract**-Plasma is one of the fastest emerging technologies conquering the world. It is a state of matter where atoms and molecules are electrically charged. Cold plasma is playing a very important role in almost all the fields of technology. It has witnessing the growth in scientific and industrial areas. It has extraordinary potential because of its rare characteristics such as flexibility capability and formation of new product. In addition to it plasma technology is environment friendly and saves allot of energy, due to which it finds its application in various fields. Plasma technology has emerged out as a great way of managing the waste. In this paper a detailed study is being done on plasma technology and its applications. This paper also gives an overview of various discharge sources and application. In this paper a deep analysis on cold plasma (non thermal plasma) is provided.

**Keywords**-Plasma, Non thermal, Dielectric Barrier Discharge, Source, etc

## I. INTRODUCTION

There are four state of matter namely solid, liquid, gas and plasma. Plasma term is derived from the inner region of electric discharge. Plasma is also called as quasi neutral gas and contains components such as atoms, molecules, electrons, positive ions, negative ions and free radicals. Plasma cannot be found in terrestrial condition but it can be generated in labs at low pressure by exciting the matter contents[1]. These matter contents can be motivated through thermal, nuclear, chemical energy, applying voltage, electromagnetic waves or sometimes combination of these two can also be employed. Energy to be applied depends upon the use of cold or hot plasma. Plasma finds its application in various fields of science. Plasma is broadly divided into thermal plasma and non thermal plasma. Non thermal plasma is also called cold or non equilibrium plasma whereas thermal plasma is also named as quasi equilibrium or hot plasma [2]. Cold plasma is used in microelectronic processing, biomedical engineering, environmental engineering, textile industries and lightning and display technology.

## II. TYPES OF PLASMA AND THEIR APPLICATIONS

Plasma are basically divided into Thermal and non Thermal plasma.

**Thermal Plasma** is characterized by the state of equilibrium achieved between electrons and atoms, molecules, ions. In Thermal Plasma temperature of electron is nearly equal to the temperature of ions [3].

When the electrical power changes into thermal enthalpy, it generates heat flux this feature of thermal plasma is used in making plasma torches, arc plasma, etc. Thermal plasma finds its application in waste management and Processing of material.

(i)Waste Management: Thermal Plasma is used for the gasification of waste products (paper, biomass, plastic).

(ii)Regeneration Of gases: Thermal Plasma is even used in regeneration like natural gas, hydrogen and hydrogen rich gases.

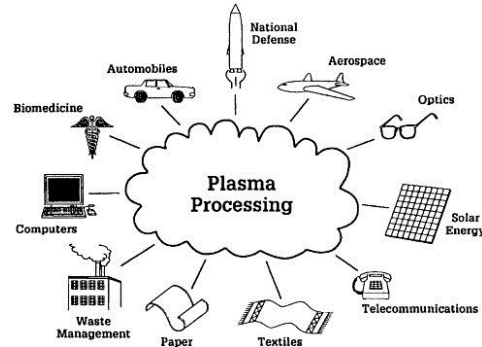
(iii) Processing of material: Thermal Plasma is being used in surface hardening. Surface coating by Plasma made chemicals.

### Non Thermal Plasma

In cold Plasma non equilibrium state is achieved between electron and atoms, molecules, ions. When the temperature of electron is greater than the temperature of atoms, molecules, ions (heavy particles) it is specially known as cold plasma[4]

Cold Plasma is finding its application in material processing, environmental engineering, biomedical field and textile industry [5]. It is also being used in lighting and display devices because of its unique temperature characteristics.

Different electrical discharge technique like corona discharge, barrier discharges, micro hollow cathode discharge, atmospheric pressure plasma jet are being used to generate NTP's.



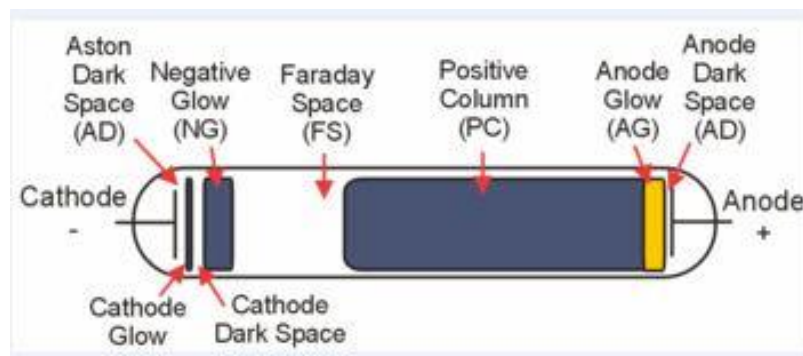
**Fig 1: Applications of Plasma**

### III. ELECTRICAL DISCHARGES

(i)Low Pressure Glow Discharge: It is created by applying voltage between two electrodes in a glass tube containing gas[5].When the voltage exceeds the certain value(called striking voltage), gas in the tube ionizes (here plasma is created) and starts conducting electricity and causes glowing of colored light.

Glow discharge is widely used in lighting devices, plasma screen television. It finds its application in plasma physics and analytical chemistry.

The potential difference between two electrodes in glass tube varies between anodes to cathode. It is maximum near anode and decreases to minimum near cathode..Hence the regions are created between anode and cathode. The regions are named as Aston dark space, cathode glow, cathode dark space, faraday dark space, positive column anode dark space and anode glow.



**Fig 2: Low Pressure Glow Discharge**

### IV. NTP GENERATION SCHEMES

Formation of NTP's at atmospheric pressure has been gaining its popularity rapidly. Researches are taking interest in generation of NTP at atmospheric Pressure as it has lot of advantages over old techniques of creating NTP. Unlike the old technique of low pressure discharge NTP at atmospheric pressure do not make use of vacuum system [6].It gives high throughput thus leading to lowering the cost. A number of atmospheric sources find its application in industries as they work at 1 atm. These NTP generation techniques are discussed in below section.

#### (A)Corona Discharge

When a dc voltage (pulsed or continuous) is applied to electrodes which are arranged in an uneven manner, electric field is generated around the electrodes. This gives rise to the discharge called as corona discharge. Corona discharge is developed around pointed corners of the electrode atmospheric pressure. Corona discharge techniques uses pointed electrodes or wire electrodes. In wire like electrode a crown like structure is created [6]. This crown like structure is formed due to the discharge which is formed due to the application of non uniform electric field.

The process of creation of plasma take place when the high electric field is applied to the electrodes (pointed por wired) Due to The high electric field applied on the gas, breakdown strength of gas is crossed and the gas get ionized leading to the formation

of weak ionized plasma [7] There are two types of Corona Discharge namely Positive Corona Discharge and negative Corona Discharge. Positive Corona is formed when the electrode with comparatively better curvature is conned to negative end of power supply while in positive corona strong curvature electrode is connected to positive end of battery. Corona discharge is implemented in electrostatic precipitators, copying machine, powder coating and liquid spray gun.

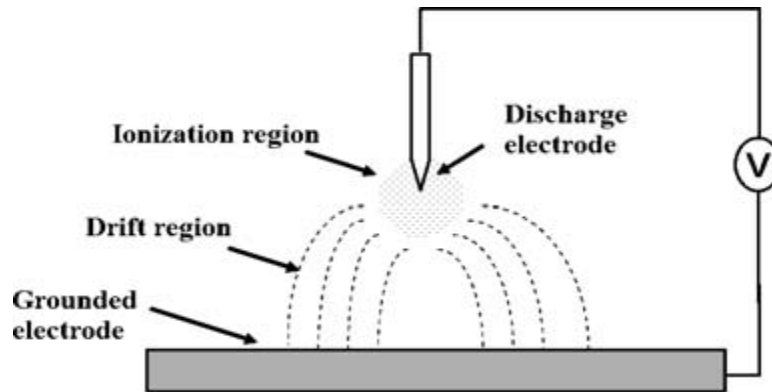


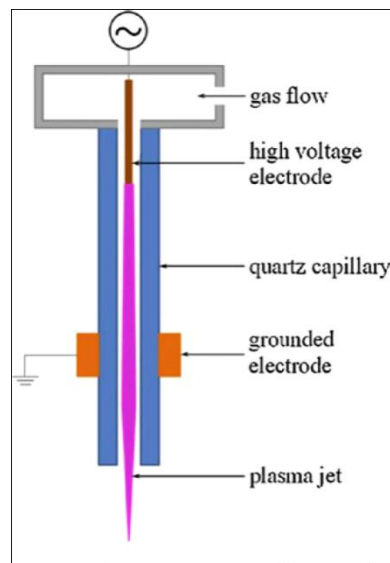
Fig 3: Corona Discharge

### (B) MICRO HOLLOW CATHODE DISCHARGE

Micro Hollow cathode discharge make use of micro hollow cathode to produce NTP .The current density produces in linear discharge is very less as compared to the one produced by modifying cathode shapes in linear discharges[8].Due to the modification done to the cathode this discharge has got its name as hollow cathode discharge. Hollow cathode discharge is employed with the cathode which has a hole or cavity. For High Pressure work HCD's diameter of hole is decreases to few micrometers at atmospheric pressure. When the diameter of whole lies typically in the range of micrometer range then it is named as Micro Hollow Cathode Discharge. MHCD is used in curing of gaseous pollutant, medical sterilization, and biological decontamination.

### (C)ATMOSPHERIC PRESSURE PLASMA JET

Generating cold plasma by applying the high frequency fields is one of the efficient methods under the category of atmospheric pressure low temperature plasma sources [9].A combination of gases like helium, oxygen or other gases made to run inside the two concentric electrodes. The positioning is done in such a way that the inner electrode is coupled to high radio frequency(13.6 MHz) at a voltage ranging from 100-250Vwhile the outer electrode of concentric arrangement is grounded. A very accelerated flow of chemicals is generated when high frequency power is implemented on discharge to get it ignited and then the gases flows between the two electrode setup. Atmospheric Pressure Plasma jet finds its uses in etching polyamide, tungsten and silicon dioxide; Decontamination of chemicals; sterilize surgical; dental equipments and hospital surface.



**Fig 4: Atmospheric Pressure plasma jet****(D)PLASMA NEEDLE**

One of the most influential technique in biological field of producing cold plasma is Plasma Needle technique[10].It has a single electrode arrangement and it works in helium. A fine needle is placed inside the plastic bag which is linked to a gas supply. High frequency current is then given to the needle. A very high electric field is created near the tip as the tip is sharp and pointed while electric field is less in another region of needle.

Due to its capability of working on irregular surfaces, smaller penetration depth and high precision and minimum penetration it is proving a boon in surgical, medical and biological areas such as bacterial contamination, removal of unwanted cells, skin treatment.

**V. CONCLUSION**

In this paper Plasma is thoroughly discussed and a detailed study of Non thermal plasma and their applications in various fields (Environmental Engineering, Biomedical field, lighting and display devices, textile sector, Material processing glow) is done. It is concluded that even though plasma's applications are innumerable, there is a lot of scope of research in this field and hence the area of cold plasma is still open and gaining the interest of researchers in order to add some more applications to it

**REFERENCES**

- [1].Roth J R, Industrial Plasma Engineering: vol.1-Principles, IOP, 1995.
- [2].John P I, Plasma science and creation of wealth, Tata McGraw Hill, 2005.
- [3]. I. Boulos, "Thermal plasma processing", *IEEE Trans. Plasma Sci.*, vol. 19, Dec. 1991
- [4]. Dobrin D, Magureanu M, Mandache NB, Ionita MD, The effect of non-thermal plasma treatment on wheat germination and early growth. *Food Science and Emerging Technologies*, 29, 2015.
- [5].B. Eliasson, U. Kogelschatz, "Nonequilibrium volume plasma chemical processing", *IEEE Trans. Plasma Sci.*, vol. 19, Dec. 1991
- [6] M. A. Lieberman, A. J. Lichtenberg, *Principles of Plasma Discharges and Materials Processing.*, 1994.
- [7].Chang J S *et al*, Corona discharge processes, *IEEE Trans Plasma Sci*,19,1991.
- [8] Tendero C *et al*, Atmospheric pressure plasma :a review,*Spectrochimica Acta Part B*,61,2006.
- [9]. Fridman A *et al*, Non –thermal atmospheric pressure discharge,*J Phys D:Appl Phys*,38,2005
- [10]. Sladek R E and Stoffels E,Deactivation of Escherichia coli by plasma needle, *J. Phys :Appl. Phys.*,38,2005.