COMMUNICATION SCIENCE ET TECHNOLOGIE
Vol 21, N°02, pp15, 20
ENPO – Maurice AUDIN
ASJP/ ESSN 2773-3483

THE DIFFERENT APPLICATIONS OF A DIELECTRIC BARRIER DISCHARGE FILLED WITH ARGON

S. BELOUADI[1], N. LARBI DAHO BACHIR[1,2]

[1]Laboratoire de physique des couches minces et matériaux pour l'électronique, Université ORAN 1

[2]Laboratoire de Physique des Plasmas, des Matériaux Conducteurs et leur Application, USTO-MB
Reçu le:28/09/2023 *Accepté Le: 12/09/2023*

ABSTRACT

Dielectric barrier discharge (DBD) is a well-known method for producing homogeneous glow discharges at high pressures. These systems have many applications, such as ozone generation, excimer UV lamps and plasma display panels [1]. DBDs are successfully applied to pollution control and to polymer surface treatment in order to promote wettability, printability, and adhesion [2]. The recent investigations [3, 4] showed that they find several applications in the biomedical field; the light disinfection systems used in health care settings is an attempt to decrease the transmission of nosocomial pathogens and prevent health care associated infections [5]. The atmospheric pressure barrier discharges filled with the noble gas Argon using excimer lamps is studied as a perspective plasma-processing system for surface treatment, bio-medical and the disinfection of surfaces due to their practical, inexpensive and appropriately intense advantages.

Keywords: Dielectric barrier discharge;Argon;Applications;UV radiations.

Author Correspondence, e-mail: belouadisarra@gmail.com

https://www.asjp.cerist.dz/en/PresentationRevue/42

1. INTRODUCTION

For more than a century, cold plasma physics has been of great interest from a theoretical and experimental point of view. To produce this type of plasmas on an industrial scale, one can apply an electric field in a glass enclosure filled with a pure gas or gas mixture with two flat and parallel electrodes. The motion of electrons in this geometry generates a series of ionizing collisions, therefore a plasma is created. The purpose of the study of electric discharge plasma (outside thermodynamic equilibrium) is to better understand the basic phenomena in order to better understand the physico-chemical properties of plasma.

However, creating a stable high-pressure discharge represents a huge challenge. For this, we chose the dielectric barrier discharge technique DBDs filled with a rare gas, which is the Argon due to these industrial advantages to carry out this work. The physico-chemical properties of argon plasma make DBDs particularly well suited for the operation of excimer lamps.

1.1. Excimer lamps

An excimer (or excilampe) lamp is a source of ultraviolet light produced by spontaneous emission of excimer molecules (exciplex).The principle of these lamps is based on an electric discharge in a rare gas or a mixture of rare gases or a mixture of rare gases and hallogenes in order to excite their molecules knowing that the rare gases have the property of having a valence layer filled with electrons; which means, it takes at least a sufficiently high energy (about 10 eV) to allow the formation of an excimer molecule. Excimers are often diatomic and are composed of two atoms or molecules that would not bind if the two were in the fundamental state, their lifespan is very short (order of nanosecond). Excimers spontaneously transit from the excited state to the fundamental state, resulting in the emission of UV photons. An active excimer molecule specifies the maximum spectral radiation of the excimer lamp.(See table1)

Table 1. Wavelength and photonic energy of excimer lamp radiation

excimer molecules	**Wavelength (nm)**	**Photonic energy (eV)**
Ar_2^*	126	9.48
Kr_2^*	146	8.49
Xe_2^*	172	7.21

Recently, dielectric barrier discharge has become the most common type used in commercial lamps. One advantage of DBD excimer lamps is that the electrodes are not in direct contact with the active environment (plasma). The lack of interaction between the electrodes and the discharge eliminates the corrosion of the electrodes and the contamination of the active environment by the powdered electrode material, which significantly increases the lifespan of the DBD excimed lamps compared to others. They also allow the elimination of mercury lamps, which is toxic. In addition, a dielectric barrier discharge ensures efficient excitation of a gas mixture in a wide range of operating pressures ranging from a few torrs to more than one atmosphere. Excimer lamps can be manufactured in any desired shape of the radiant surface, meeting the requirements of a specific task.

1.2 DBDs Discharge Configurations

There are different configurations of DBDs dielectric barrier discharges. The term DBD refers to all discharge cell configurations where a current passes between two metal electrodes separated by a gas and at least one layer of an insulating material. In the following figure, we represent the different DBDs configurations that are mainly targeted according to their applications. (See fig.1)

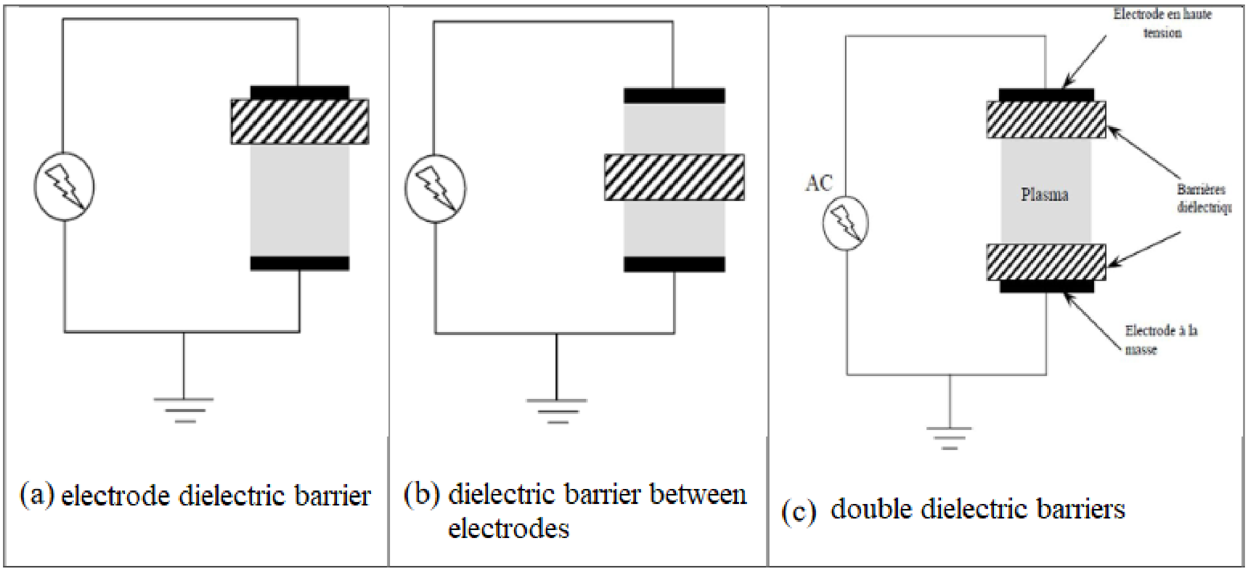

Fig.1.different configurations of DBDs.

Figure.1. (a): The electrode dielectric barrier discharge configuration is particularly suitable for gas treatments or UV generation.

Figure.1. (b): The configuration of the dielectric discharge between the electrodes allows the simultaneous obtaining of two discharges on both sides of the dielectric, which can even be the material to be treated.

Figure.1. (c): The configuration of the double dielectric barrier discharge has the advantage of avoiding any contact between the plasma and the electrodes, a condition sometimes useful when using a corrosive plasma.

2. RESULTS AND DISCUSSION

2.1. Argon

In 1894, Lord Rayleigh and William Ramsay discovered a third air component after oxygen and nitrogen called Argon gas. It represents 0.934% by volume of air. It is a colourless, tasteless, non-toxic, non-flammable and monoatomic gas. The name "Argon" derives from the

Greek word "Argos" meaning lazy, idle and inactive in reference to this element, which is chemically inert and is part of the rare gases. The properties of Argon are presented in the table bellow. (See table 2).

Table 2. The physico-chemical properties of Argon

Properties	***Value***
Atomic number (Z)	18
atomic weight (u.m.a)	39.95
electrical configuration	$1s^2 2s^2 2p^6 3s^2 3p^6$
atomic radius (pm)	88
valence radius (pm)	98
number of protons	18
Nombre of neutrons	22
crystalline structure	Cubic centred face
1st ionization energy (eV)	15.759610
Isotopes at atmospheric pressure	^{40}Ar(99.5%) , ^{36}Ar(0.35%), ^{38}Ar(0.06%)

2.2. Applications

Argon is the most used gas and the cheapest of rare gases, its physicochemical properties allow it to be important in various fields:

2.2.1.In food and pharmaceutical products

Due to its inertia, argon acts as a preservative to extend the expiration date of products because it inhibits chemical reactions such as oxidation and hydrolysis. In Europe, this gas is part of food additives [6].

2.2.2.In industry

In industry, argon is used as thermal and acoustic insulation in double-glazed windows and scuba suits.

Recently in Europe the halon of fire extinguishers, is replaced by argon. This type of extinguisher is used to prevent damage to sprayed equipment. It is also used in the deposition of thin layers in solar cells by cathode-ray spraying.

2.2.3.In geochronology

The various isotopes of argon are used in environmental and geological dating processes such as the ice caps underground waters. The ^{40}K-^{40}Ar dating is also effective in estimating the age of volcanic rocks.

2.2.4. In lighting

DBD lamps have the advantage of being able to produce homogeneous radiation through the surface of the electrodes; they have also allowed the elimination of mercury, which is harmful

to health, and increase the life of the lamps, because it protects the electrodes from erosion.
In these DBD lamps, the external dielectric (and sometimes the external electrode that is transparent) filters the UV, allowing only the passage of the corresponding color to a visible wavelength by presenting a homogeneous illumination. (see fig.2)

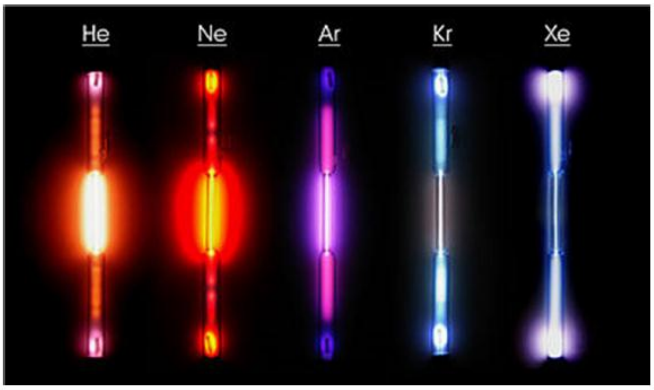

Fig.2. Excimer lamps for rare gases.

2.2.5.Medical field

DBDs have several applications in the medical field including surgery. Research has shown that direct treatment of smooth surfaces by dielectric barrier discharge (DBD) in the air is highly effective in killing pathogens. The sterilization of wound surfaces is also one of the promising applications in the medical field especially on topographically non-uniform surfaces as in most living tissues [7-8].

In dermatology in particular, applications of argon plasma have great potential in wound healing, disinfection, effective sterilization, and therapy of various skin infections or tissue regeneration.

With a cold atmospheric argon plasma device the technique is safe, painless and effective to significantly reduce the bacterial load of chronic wounds regardless of the type of bacteria and their level of resistance. Argon plasma coagulation is an electro-surgical procedure used to reliably interrupt bleeding and devitalize tissue. Unlike laser, APC involves the transmission of energy between the electrode and the target tissue through an electric field, not optically. The argon plasma jet follows the path of lowest electrical resistance. (See Fig.3)

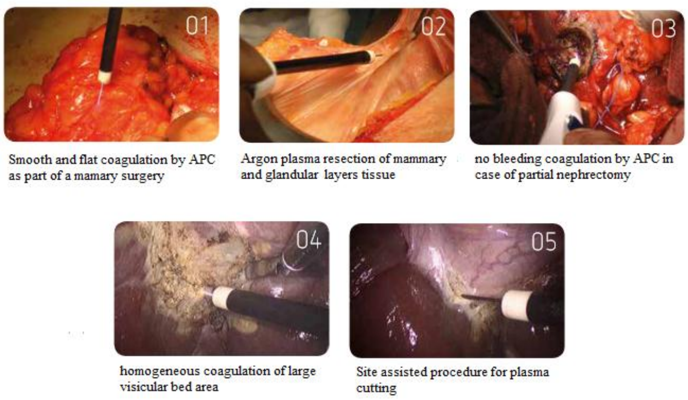

Fig.3. Coagulation by APC method.

3. CONCLUSION

DBDs are of great interest. Its abundance and its physico-chemical properties as well as its UV and far UV luminance motivate the use of Argon. Improving the efficiency of excimer lamps is essential to diversify applications and optimize the operating efficiency of this type of lamps.

4. REFERENCES

[1] Kogelschatz, U.,J. Plasma Chem. Plasma Process. 2003, 23, 1-46,doi : 10.1023/A:1022470901385

[2] A. Chirokov, A. Gutsol, A. Fridman., J. Pure and Applied Chemistery.2005, 77(2):487-495,doi: 10.1351/pac200577020487

[3] M. Laroussi., J. IEEE, Transactions on Plasma Science. 2009, 7 (1), 113-118, doi: 10.1109/TPS.2009.2017267

[4] G. Fridman, A. Shereshevsky, M.M. Jost, A.D. Brooks, A. Fridman, A. Gutsol, V. Vasilets, G.Friedman., J. Plasma Chem. Plasma Process. 2007, 27, 163-176, doi: 10.1007/s11090-007-9048-4

[5]Hessling M, Haag R, Sieber N, Vatter P., J. GMS Hyg Infect Control. 2021, 33643774, doi: 10.3205/dgkh000378.

[6] A. Mullie. Les gaz a usage medical, des produits therapeutiques pas comme les autres : aspects specifiques de l’application de la legislation pharmaceutique, de son enregistement a sa distribution. Doctorat thesis. Université Joseph Fournier, Faculte de pharmacie,. Alpes, France., 2010.

[7] M. Vandamme, É. Robert, S. Lerondel, J-M. Pouvesle, and A. Le Pape., J. Med Sci (Paris). 2012, 28(2): 154–156,
doi: 10.1051/medsci/2012282013.

[8] M. S. Limam., La bio decontamination de surface par plasma froid contribution par l’étude de procédés de traitement de surface à pression atmosphérique. Doctorat thesis, Université Paris-Saclay EOBE, Paris, France.2019.