# Effect of applied frequency on the number of micro-discharge in dielectric barriers discharge

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Dielectric barrier discharge is widely used as a method for generating cold plasma for surface modification, sterilization, germination, and ozone generation. One of the important parameter is power discharge, which can be controlled by many ways such as adjusting voltage, frequency and pulse density of applying signal for plasma electrodes. This research focus on the number of micro-discharge at difference frequency of applying signal. The measured resistor is installed between the electrode and negative port of power supply for measuring the signal of micro-discharge. The frequency is adjusted for 5 kHz, 8 kHz, 10 kHz, 12 kHz and 14 kHz and the average number of micro-discharge found to be 75.75, 60.50, 110.25, 270.25 and 297.25, respectively.

## Introduction

Dielectric barrier discharge (DBD) is one of many methods that can produce cold plasma in atmospheric pressure, thus making DBD popular and widely used. There are various methods to control the plasma power such as the frequency change of voltage supply or the positive moments of electrical signals [1], R.-F. Horng et al studied the amount of hydrogen gas generated from methane plasma systems by varying the frequency of the high voltage power supply in the range of 57-250 Hz, the concentration of hydrogen gas increased. When the frequency is higher which is range about 100-250 Hz, the concentration of hydrogen gas increases compared to the low-frequency range. When considering the power of the plasma, the plasma power will increase quickly as the frequency of power supply increases and peaks at 125 Hz. At a higher frequency, the electrical power will decrease slowly. [2], Li et al. used the plasma discharge graft filling technique to improve dielectric barriers discharge for separating the gas by using 10 kHz separation membranes and controlling the plasma attribute by adjust the input voltage and time. When increased the voltage, is found that the permeation flux decreases until the voltage stable at 70 volts which is the degree of grafting in membranes [3]. Another method to control the plasma power is that changing the number of signals that is sent to electrode in the one period of time. It is called “pulse density modulation”. It is the change of high voltage wave in a time, which cause the change of plasma power to be changed while frequency and voltage remain stable [4].

## Materials and Methods

In this research, we used the dielectric barrier discharge by fixing distant between two 4 mm electrodes (diameter of electrodes are 55 mm). 2 mm thickness Teflon plate and 72 mm diameter put between electrodes. Atmospheric pressure air is used for the experiment ($O_2$ about 20.5%, $N_2$ and other gas 79.5% measured using by Geotech, type Biogas Check Rev.0). One of the electrodes connects to a high voltage power supply at 15 kV and the Tektronix P6015A 1000x is used for measuring the voltage across two electrodes. Frequency various between 6-14 kHz.

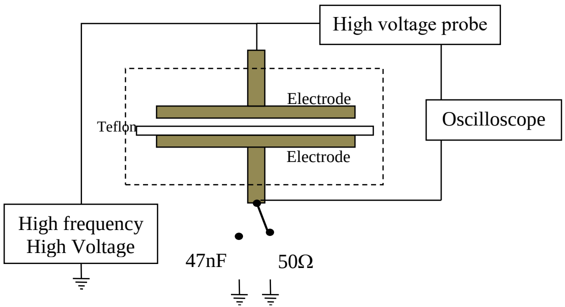


**Figure 1** Atmospheric dielectric barrier discharge system.

The equivalence of capacitance shown in figure 2.

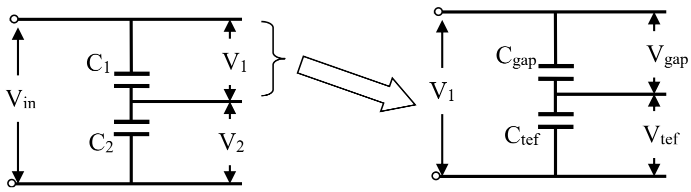


**Figure 2** Equivalence of capacitance

In fig. 1, another electrode can connect to 50Ω resistors or 47 nF capacitor. The 50Ω resistors is used for measuring discharge current. The charge of plasma can be calculated by using the following equation

$$Q = C_2 V_2 \qquad (1)$$

where Q is a charge of plasma (C), $C_2$ is capacitance which is 47 nF and $V_2$ is voltage on $C_2$ (V). Gap capacitance by equation

$$\frac{Q}{V_1} = \frac{C_{gap} C_{tef}}{C_{gap} + C_{tef}} \;,\; C_{tef} = \frac{\varepsilon_0 \varepsilon_r A}{d} \;,\; C_{gap} = \frac{C_{tef} Q}{V_1 C_{tef} - Q} \text{ and } \frac{Q}{C_{gap}} = \frac{V_1 C_1 - Q}{C_{tef}} \qquad (2)$$

From this equation, one can find the relationship between the charge on 47 nF capacitor and the electrode potential difference. which can be used to find plasma power.

## Results and discussion

The pictures of micro-discharge between the two electrodes at different with frequency are shown in figure 3. It can be clearly seen that the number of microdischarge is increased with increasing frequency.

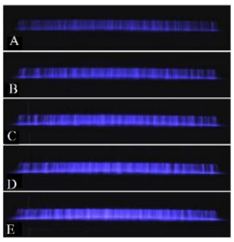


**Figure 3** Micro-discharge in dielectric barriers discharge (A) 6 kHz, (B) 8 kHz, (C) 10 kHz, (D) 12 kHz and (E) 14 kHz

From the voltage and current signal, the number of current pulses signal vary with frequency. The frequency is adjusted for 6 kHz, 8 kHz, 10 kHz, 12 kHz, and 14 kHz and the average number of micro-discharge (over 10 cycles) are 75.75, 60.50, 110.25, 270.25 and 297.25, respectively. Shown in Figure 4.

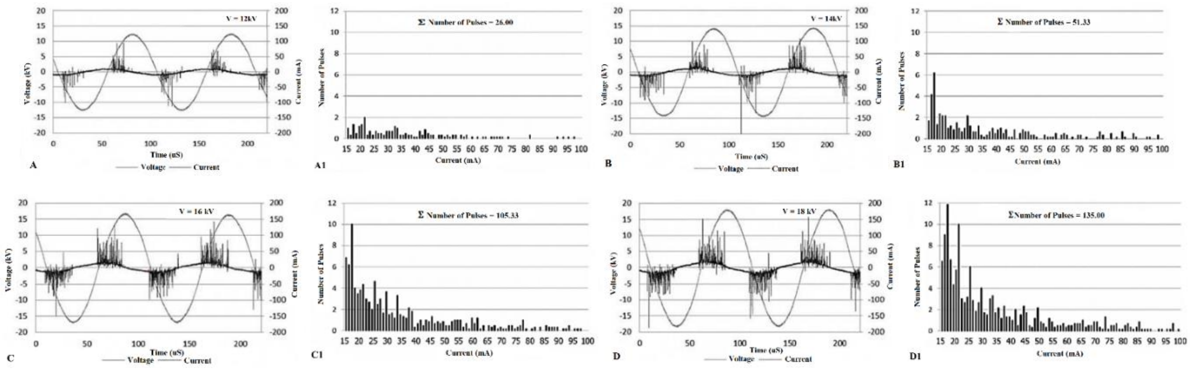

**Figure 4** Number of micro-discharge (A) 6 kHz, (B) 8 kHz, (C) 10 kHz, (D) 12 kHz and (E) 14 kHz

The number of current pulses increases when electrical power increases. The plasma power can be calculated by the relationship between the charge on 47 nF capacitor and the electrode potential difference. Shown in Table 1.

**Table 1** Plasma power with Electrical frequency

| Electrical frequency (kHz) | Plasma power (W) |
|---|---|
| 6 | 20.44 |
| 8 | 28.40 |
| 10 | 34.89 |
| 12 | 42.12 |
| 14 | 41.44 |

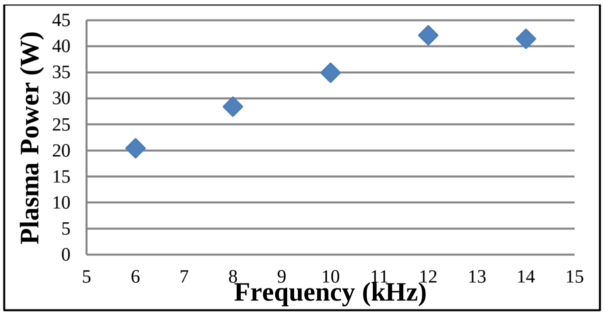


**Figure 5** Plasma power and electrical frequency

When increasing the electrical frequency between 6 kHz and 12 kHz, the plasma power will be increased. At 12 kHz, while the plasma power does not change or decrease slowly, the number of pulses increases. Meaning that the micro discharge increase but plasma power does not change. It can be seen that the micro-discharge power increase (better conductor) whereas the plasma resistance decrease.

## Conclusions

The number of micro-discharge at different frequency on the dielectric barrier discharge will be studied.

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## Acknowledgments

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