Oral presentation | 8 Plasma Electronics：8.6 Plasma Electronics English Session

Thu. Sep 21, 2023 5:00 PM - 5:45 PM JST | Thu. Sep 21, 2023 8:00 AM - 8:45 AM UTC | A302 (KJ Hall)

[21p-A302-12~14] 8.6 Plasma Electronics English Session

Satoshi Kitazaki(Fukuoka Inst. of Tech.)

English Presentation
5:00 PM - 5:15 PM JST | 8:00 AM - 8:15 AM UTC

[21p-A302-12] Evaluation of Reactive Species Production in Atmospheric Pressure Air Discharge Using a Back-Illuminated Photocathode

〇Sukma Wahyu Fitriani[1], Hideki Yajima[2], Akimitsu Hatta[1] (1.Kochi Univ. of Tehcnol., 2.ORC Manufacture)

Presentation by Applicant for JSAP Young Scientists Presentation Award English Presentation
5:15 PM - 5:30 PM JST | 8:15 AM - 8:30 AM UTC

[21p-A302-13] Pressure Wave Formation of Atmospheric Pressure Plasma Jet by Optical Wave Microphone Measurement

〇THUZAR PHYO WAI[1], MITSUGI FUMIAKI[1] (1.Kumamoto University)

Presentation by Applicant for JSAP Young Scientists Presentation Award English Presentation
5:30 PM - 5:45 PM JST | 8:30 AM - 8:45 AM UTC

[21p-A302-14] Investigation on the Pressure Wave influence of the ROS Distribution measured with Optical Wave Microphone

〇Myo HtetHtet Nway[1], Mitsugi Fumiaki[1] (1.Kumamoto University)

Evaluation of Reactive Species Production in Atmospheric Pressure Air Discharge Using a Back-Illuminated Photocathode

Kochi Univ. of Technol. [1], **ORC Manufacturing.** [2], **°Sukma Wahyu Fitriani** [1†], **Hideki Yajima** [2], **Akimitsu Hatta** [1*]

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Low-temperature atmospheric pressure plasmas (LTPs) produce reactive oxygen and nitrogen species (RONS) when reacting with biological materials, such as hydrogen peroxide H_2O_2, hydroxyl OH, nitrite NO_2^- and nitrate NO_3^-. This process plays an important role for medical and agricultural applications. RONS could lead to cell death pathways by triggering cell signal cascades. Simultaneously, it has benefits for the growing process of plants. However, generating stable and uniform plasma in atmospheric pressure is still a challenging issue. Photoemission-induced gas discharge is an alternative to produce stable DC plasma even in atmospheric pressure conditions [1].

Fig. 1. shows an experimental set-up of this work. A photocathode was fabricated by depositing nano gold thin film on the quartz glass which was externally illuminated using an excimer lamp with a wavelength of 172 nm and 222 nm. The production of reactive species was examined by measuring the UV absorbance of discharged gas dissolved in deionized water.

The current-voltage relationship of air discharge with different UV wavelengths is shown in Fig. 2. A stable and continuous gas discharge was achieved by using both 172 nm and 222 nm. As the voltage increases, the current increases, then nearly saturated and followed by an exponential increment. However, different UV power density resulted in different current values.

Fig. 3 shows a comparison of UV absorbance using 172 nm and 222 nm. In the case of 172 nm, a peak around 260 nm was found which corresponds to ozone O_3 diluted in the water. In addition, the tail of the peak at a wavelength below 220 nm was detected also. Deconvolution analysis showed that this peak can be attributed as NO_3^-, H_2O_2, O_2, and OH^-. In contrast, for 222 nm, a single peak at wavelength around 210 nm was found. It can be assigned as NO_2^- peak and the small peaks of reactive oxygen species. This result suggests that production of strong oxidizing species can be suppressed by using 222 nm UV light for the photoemission.

References: [1] APEX, **15**, 116001 (2022)

†Current affiliation: Kyushu University

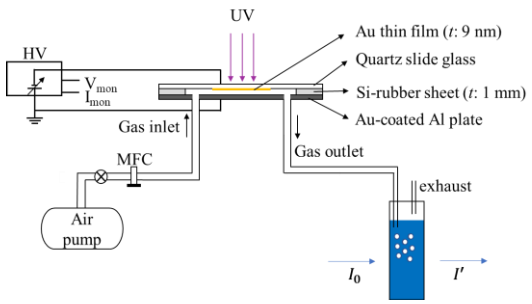

Fig. 1 Experiment set-up illustration.

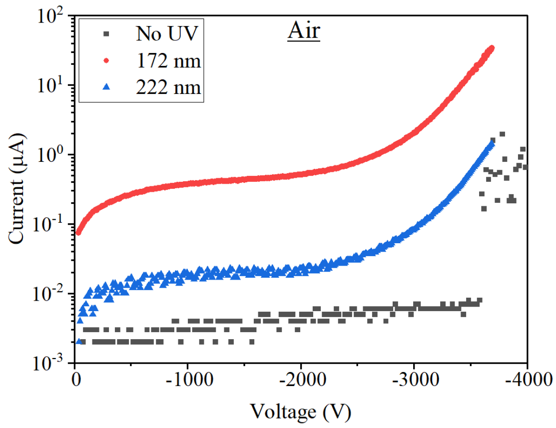

Fig. 2 Current-Voltage characteristic.

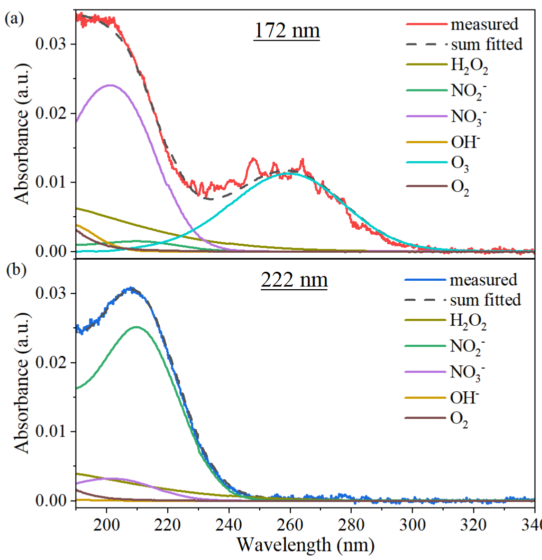

Fig. 3 Absorbance of gas discharge dissolved in water using UV lamp of (a) 172 nm (b) 222 nm.

Pressure Wave Formation of Atmospheric Pressure Plasma Jet by Optical Microphone Measurement

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1 Introduction

One of the most important observations on what plasma jets emit is pressure waves which have been focused on energic distribution of electric discharges in atmospheric pressure. Some optical methods such as schlieren and shadowgraph are not sensitive to detect very small refractive index changes such as pressure waves. In the previous studies, a unique optical technique called optical wave microphone technique had successfully detected shockwaves emitted a helium plasma jet was also successfully done at the downstream of the plasma jet in the frequency order of kilohertz.

2 Experimental Setup

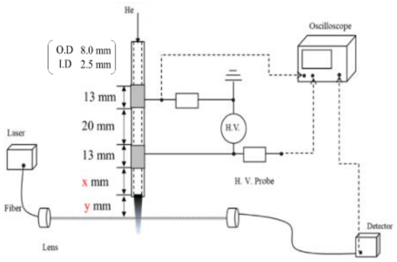


Fig.1Schematic diagram of experimental setup

The experimental setup is composed of an atmospheric pressure plasma jet (APPJ) and an optical wave microphone. Sinusoidal high voltage of 10 kV was applied to the powered electrode by using a function generator (NF-WF1974) and an amplifier.

3 Results and Discussion

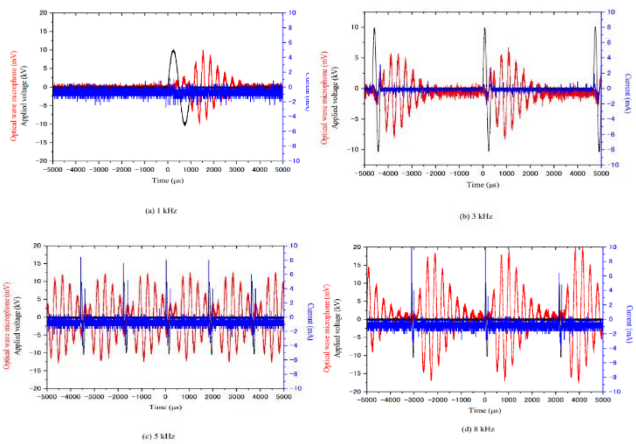


Fig.2. Comparison of optical wave microphone waveforms by changing applied voltage frequency (1kHz, 3 kHz, 5kHz, 8kHz)

In Fig.2, when the applied voltage frequency is increased, the pressure wave at one period of voltage application reaches the measurement level. The pressure wave formation due to the next voltage application reaches the measurement part again, and the optical microphone waveforms overlap each other. Since the measurement result at one period of the applied voltage is not known, the burst interval period is changed for each applied voltage frequency. As a result, the intensity of the pressure wave is increased as the applied frequency is also increased. When the waveform of the pressure wave was checked at a few 12 kHz, the intensity was less than 8 kHz. The pressure wave intensity was highest at 8 kHz.

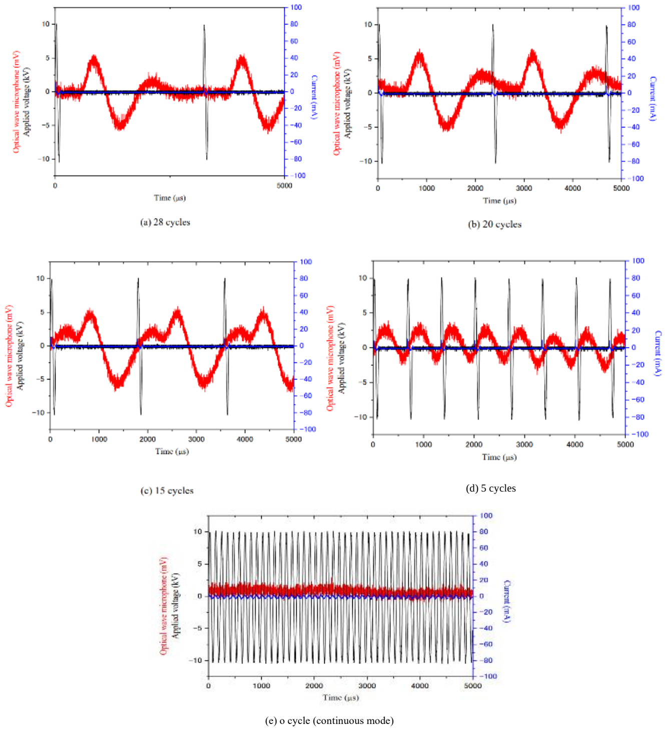


Fig.3 Optical wave microphone waveforms with different burst interval period (a) 28 cycles, (b) 20 cycles, (c) 15cycle, (d) 5 cycles and (e) 0 cycle

In fig.3, pressure waves formation is changed when several burst interval period cycles are used by starting interference with overlapping of waves each other. It can be seen that pressure wave signals overlap each other and it becomes nearly zero at 5 cycles interval and continuous mode of 0 cycle.

4 Conclusion

The intensity of pressure wave formation is also influenced by changing of applied voltage frequency. Pressure wave signals with superimposing stages were found by shortening the burst interval based on changing burst interval period in cycles and the value could be reduced to almost zero when continuous mode is used.

References

[1] F. Mitsugi, S. Kusumegi, T. Nakamiya, Y. Sonoda and T. Kawasaki, "Distribution of Pressure Wave Generated by Atmospheric Plasma Jet Measured with Optical Wave Microphone," *in IEEE Transactions on Plasma Science*, Vol.47, no.2, pp.1063-1070, Feb.2019.

Investigation on the Pressure Wave influence of the ROS Distribution measured with Optical Wave Microphone

Nway Htet Htet Myo*, Fumiaki Mitsugi*
(Kumamoto University)

1. Introduction

Plasma jet has been widely used in various applications such as nanotechnology, agriculture and biomedical treatment. Investigation on the distribution of reactive oxygen species in the target medium is one of the most important factors to understand the working mechanism of the plasma jet. In this study, it was focused on burst cycles of the applied voltage on the generation of pressure waves during plasma generation as a factor for the plasma induced liquid flow. The gel reagent with iodine-starch reactions was used as the target to visualize and investigate on the reactive oxygen species (ROS) distribution with the present of pressure waves.

2. Experimental Set up

The experimental setup is composed of an atmospheric pressure plasma jet (APPJ) and the optical wave microphone. In this experiment, a burst mode operation was used in the function generator with 20 kV applied voltage with 9 kHz applied frequency and the burst interval period between voltage cycles of the applied voltage in cycles was varied by 25 cycles, 10 cycles, 1 cycle and 0 cycle (continuous mode) to control the pressure wave formation. Also, potassium iodide (KI)-starch gel reagent was used to visualize the ROS distribution pattern that are affected by the pressure signal and the irradiation distance to the gel reagent was set to 10 mm.

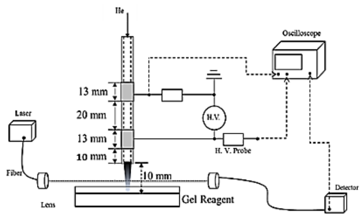
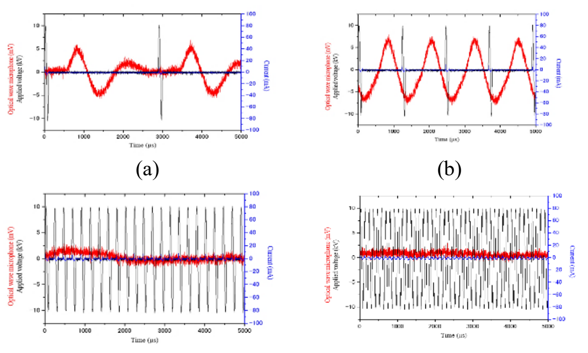


Fig.1. Experimental setup of the APPJ with a KI -starch gel target.

3. Results and discussion

To investigate the influence of the interval of the frequency of applied voltage on the pressure wave signal, the applied voltage with different burst mode cycle spaces was applied to the plasma jet and the pressure wave signal for each cycle spaces were obtained by optical wave microphone measurement.

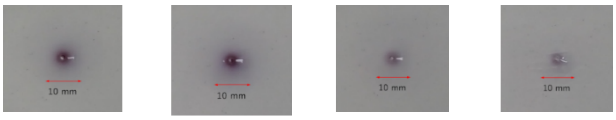


(a) (b)

(c) (d)

Fig.2. Applied voltage, discharge current, and optical wave microphone waveforms for plasma jet with different burst interval period in cycles (a) 25 cycles, (b) 10 cycles, (c) 1cycle, and 0 cycle (continuous mode)

As can be seen in Fig.2, it was shown that the pressure wave signal also depends on the burst interval between voltage cycles of the applied voltage and by shortening the burst interval by changing burst interval period in cycles causes the superimposing the pressure waves and the value could be reduced to almost zero when the cycles space is one. It means that the burst interval period between the voltage cycles of the applied voltage can control the pressure signal that is one of the factors to cause the plasma induced liquid flow.



(a) (b) (c) (d)

Fig. 3. Distribution patterns of ROS supplied into gel reagent by plasma with different burst interval period in cycles (a) 25 cycles, (b) 10 cycles, (c) 1cycle, and (d) 0 cycle (continuous mode) with a fixed 22522 times of plasma irradiation

From Fig.3, the strong ROS distribution via color distribution pattern in gel reagent with 25 cycles and 10 cycles where the pressure wave signal propagation from the plasma jet is the strongest as mentioned in optical wave microphone measurement. It can be seen the less color distribution via ROS distribution in gel reagent at 1 cycle and 0 cycle compared to 25 cycles and 10 cycles of burst interval period between applied voltage cycles.

(a) (b) (c) (d)

Fig. 4. Formation of the cycled shape non-colorization area and ROS distribution patterns in gel reagent with different gas only time duration (a) 90s, (b) 180s, (c) 360s, and (d) 540s, and 2.5s plasma irradiation time duration with 22522 numbers of applied voltage cycles

From Fig .4, the diameter and size of the non-colorization area is increased with the increase in time duration of the gas only streaming and it can be concluded that the size of the circular shape in the middle of the gel reagent depend on the time duration of gas only streaming before plasma irradiation.

4. Conclusion

In this study, the optical wave microphone was applied to the plasma jet operated by burst sinusoidal applied voltage to measure the pressure waves during plasma generation and it was found that the burst interval period of the applied voltage can control the pressure signal that is one of the factors to cause the plasma induced liquid flow and ROS distribution in the target medium.