20PA-059

Discharge character of micro plasma in water
水中マイクロプラズマの放電特性

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Microplasmas in an amibent air and in DI water have been investigated to understand electrical and optical properties. It was observed that there is a delay time of around 10 μs. It believed that a preheating process was existed during the discharge delay when nano or micro bubbles were generated, and eventually discharge plasma was ignited.

1. Introduction

Underwater discharge plasma research has a very long history, it has been developed for treatment of polluted water simultaneously developing industry and increasing population since the mid- 1900s. The discharge phenomena have been well studied with developing of high voltage pulse power technology [1-3]. A point-to-plate (or point-to-point) is a well-known electrode configuration for the electrical discharge in liquid. In the early studies, electrode gap is typically increased up to a few cm and the amplitude of the applied voltages are from several ten to hundred kilovolts. The large electrode gap and high voltage (or current) provide large volume streamer discharge. The discharge activates the liquid physically and chemically, for examples, an intense uv emission, overpressure shock waves and sufficient active species (H•, O•, OH•, O_2•, HO_2•, H_2O_2 and O_3) were induced as results [4]. The method aimed massive productions of the physical and chemical effects and suggested to solve environmental issues such as a water treatment at the early stage of this kind of studies as mentioned above.

On the other view point of chemical analysis of liquid, the underwater discharge can be a good analytical method for investigation of the composition of aqueous solutions. There is an example of analytical approach by Ichiki *et al*, [5] demonstrated the optical emission spectroscopic analysis of injection of the liquid sample into microplasma jet as the analytical view point. However, the microplasma jet is a dynamic method which is easily influenced by carrier gas condition. We here developed a point-to-plate underwater microplasma which can be operated several hundred volts and the plasma source aiming on-site analysis of chemical composition of liquid.

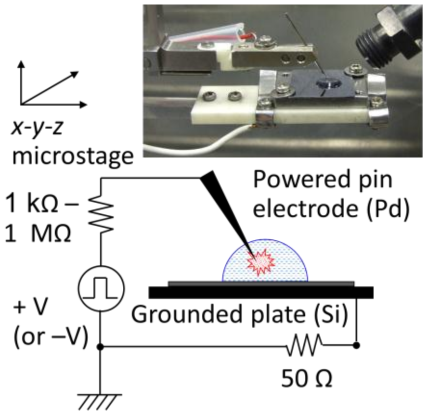

Fig. 1 Pin-to-plate microplasma with a photograph.

In this work, we measured the voltage and current of microplasmas working either in ambient air or under water.

2. Experimental method

Microplasma with a pin-to-plate configuration was used as shown in Fig. 1. Pin electrode was made of palladium and plate of silicon, respectively. Pin electrode was placed on an *x-y-z* micro-stage and the other plate electrode was separately placed on an *x-y* micro stage. The electrode gap was varied from 5 to 70 μm.

Positive pulsed dc high voltage up to 3 kV (or negative up to -3 kV) was applied to the pin electrode and measured by a high voltage probe (PMK, PHV662-L). A digital function generator (nf, DF1905) was connected to a custom made dc high voltage supply. Frequency between 1 and 100 Hz,

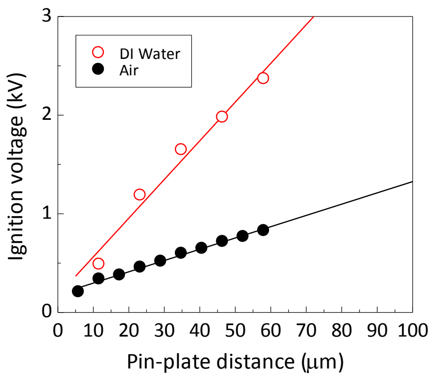

Fig. 2 Positive pulsed high voltage was applied at the pin electrode. Ignition voltages in air and water were measured as a function of pin-plate distance.

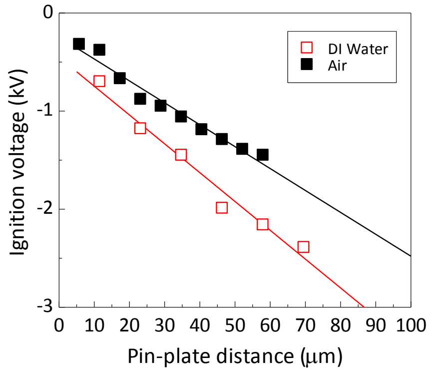

Fig. 3 Negative pulsed high voltage was applied at the pin electrode and measured ignition voltages.

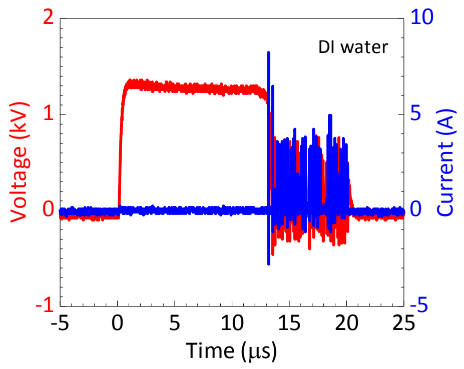

Fig. 4 Voltage and current waveforms were measured. There is a delay of 13 μs and discharge followed.

and duty between 0.1 and 1% were used. Voltage and current waveforms are displayed on a digital oscilloscope (Tektronix, TDS7254B).

3. Results and discussion

Fig. 2 shows the ignition voltages of micro-plasmas working in air or DI water as a function of distance. The pin electrode worked as an anode. The ignition voltages in both cases were linearly increased as increase of the pin-plate distance (electrode gap). The ignition voltages of DI water were always high. While, Fig. 3 shows the ignition voltages when the plate electrode working as a cathode. It was confirmed that the ignition voltage of DI water was always higher than air.

Voltage and current waveforms were measured with a fixed electrode gap of 10 μm. It was observed that a long delay time of 13 μs and spark-like discharges in Fig. 4. This is believed that a local heating is occurred during the delay time and it probably generate nano (or micro) bubbles in water. From the microplasmas in air and water, we observed typical air emission spectrum including number of peaks: the N_2 2nd positive, atomic hydrogen, and oxygen peaks, while water discharge shows a simple spectrum with atomic hydrogen.

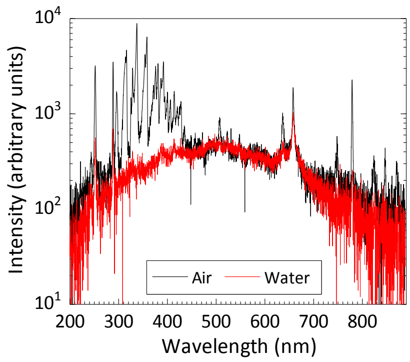

Fig. 5 Emission spectra from microplasmas in air or in water.

4. Concluding remarks

We have demonstrated a microplasma in water. The ignition voltages of the water were relatively higher than the air but it was under controlled with ±3 kV. We will discuss the electric characters of sea water microplasma on the conference site.

Acknowledgments

This work was supported by KAKEHI Grant Number 26600129.

References

[1] J. C. Devins, S. J. Rzad and R, J. Schwabe, J. Appl. Phys. **52** (1981) 4531.
[2] H. M. Jones and E. E. Kunhardt, IEEE Trans. Dielectr. Electr. Insul, **1** (1994) 1016.
[3] H. Akiyama, IEEE Trans. Dielectr. Electr. Insul, **7** (2000) 646.
[4] P. Lukes, A. T. Appleton and B. L. Locke, IEEE Trans. Ind. Appl., **40** (2004) 60.
[5] T. Ichiki, T. Koidesawa and Y. Horiike, Plasma Sources Sci. Technol. **12** (2003) S16.