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Characterization of atmospheric pressure plasma jet with double glass tube
二重ガラス管による大気圧Arプラズマジェットの特性評価

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In recent years, an atmospheric pressure plasma jet has been studied for the medical application. Recent research works revealed that OH radicals play important role for medical treatment. In this study, we developed a surrounding gas-fed plasma jet with a double coaxial glass tube configuration to control radical yield in the plasma jet by selection of the surrounding gas and the flow rate. The argon plasma jet was produced by applying a sinusoidal voltage of 8 kV at frequency of 20 kHz, while nitrogen gas flow is supplied on the periphery of the plasma jet. We measured electric and optical characteristics of the surrounding gas-fed plasma jet and the effect of the surrounding gas is investigated by comparing with the characteristics of the conventional plasma jet.

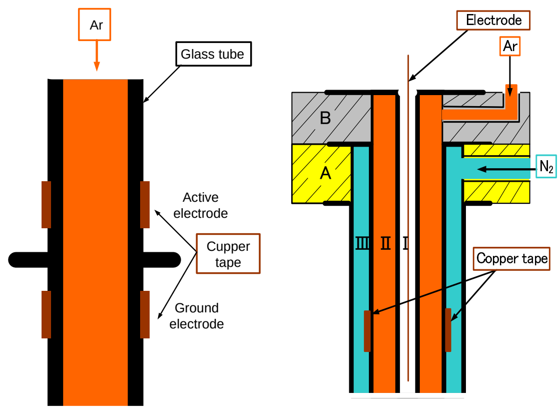
1. Introduction

Recently, the atmospheric pressure plasma jet has been attracted attentions for biomedical applications, such as sterilization, blood coagulation, would healing and even cancer treatment [1,2]. Furthermore, the plasma jets have advantages as a medical tool; operation at room temperature, easy to miniaturize and inexpensive because they do not need any vacuum system and can be operated with various feeding gases under a wide range of driving frequencies. In biomedical applications of the plasma jet, OH radicals are regarded as a key chemical reactor. In this study, we developed a surrounding gas-fed plasma jet with a double coaxial glass tube to improve OH radical yield in the plasma jet and evaluated the characteristics of the developed plasma jet by V-I characteristics and optical emission spectra analysis.

2. Experimental setup

Figure 1 (a) shows the cross-sectional view of a single glass of which size is shown in Table 1. Argon (Ar) gas flows through the tube with a flow rate of 5 slm (standard liter per minutes). The electrode gap between active and ground electrodes was 5 mm and the width of copper tapes was 5mm. Argon plasma was originally produced in the gap when the high voltage pulses applied to the electrodes. The tube edge was 40 mm away from the ground electrode. Figure 1 (b) shows the cross-sectional view of a double coaxial glass tube consisted of inner, intermediate and outer tubes for a surrounding gas-fed plasma jet. The size of each tube is shown in Table 2. The electrode was placed inside the inner tube to prevent sputtering of the electrode by the plasma. The ground electrode, a copper tape, was wrapped around the outer surface of the intermediate glass tube. The sinusoidal voltage of 8 kV with frequency of 20 kHz was applied to the electrodes. Argon (Ar) and nitrogen (N_2) gases were used as working and supporting gas, respectively. Argon gas was passed through the intermediate tube and argon plasma was produced. Nitrogen gas was passed through the outer tube.

Figure 2 shows the experimental setup. The flow rates of Ar and N_2 gases were controlled by a mass flow meter. A set-up transformer was used to generate the high sinusoidal voltage. The resistor in



(a)　　　　(b)

Fig 1. Cross-sectional view of (a) single and (b) double coaxial glass tube.

Table 1. Size of a single glass tube.

Inner diameter	Outer diameter	Length
2 mm	4 mm	130 mm

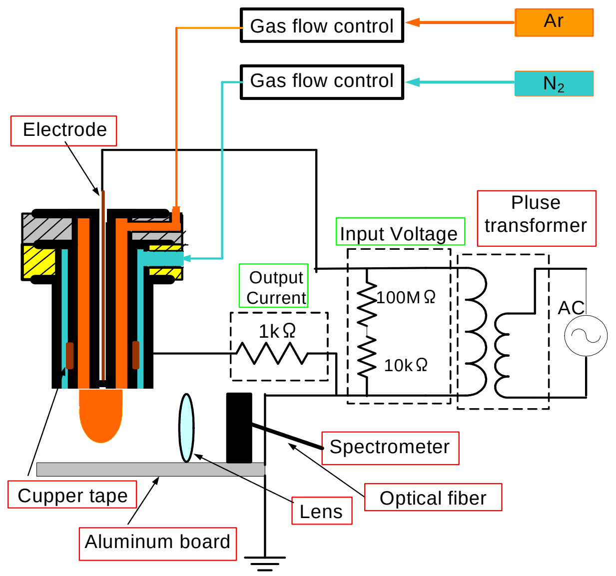


Fig 2. Schematic diagram of experimental setup.

Table 2. Size of each glass tube of the double coaxial glass tube.

	Inner diameter	Outer diameter	Length
Inner tube	2 mm	3 mm	120 mm
Intermediate tube	7 mm	9 mm	85 mm
Outer tube	13 mm	15 mm	60 mm

the circuit for the measurement of discharge current is 1 kΩ. The applied voltage was observed by the resistive divider consisted of 100 MΩ and 10 kΩ resistors. Emission spectra were measured by a spectrometer, with a double-convex lens (f = 30 mm) to collect the light into the optical fiber.

3. Experimental Results

Typical obtained emission spectrum with a single glass tube and measured input voltage and output current are shown in Fig. 3 and 4, respectively. The distance between the tip of the tube and grounded aluminum board was 50 mm and a focal spot in the plasma jet was 4 mm away from the tip. The emission spectrum of OH radical was observed at 309 nm while Ar emissions were observed in 700-900 nm. A typical characteristic of the barrier discharge was obtained in output current as ns-order pulse discharges, as shown in Fig. 4.

We are studying the characteristics of the double coaxial glass tube.

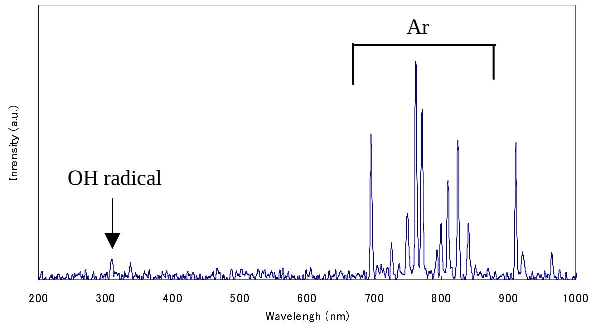


Fig 3. A typical emission spectrum of Ar plasma jet produced by a single glass tube.

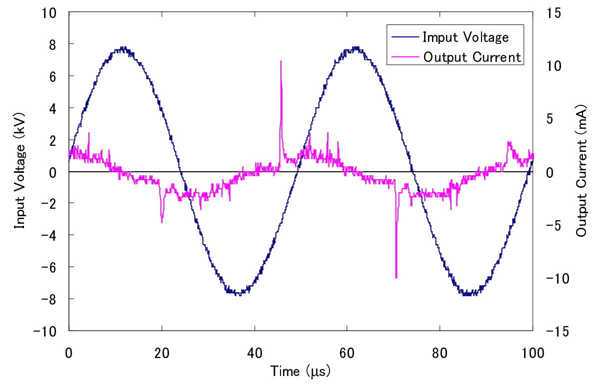


Fig 4. Measured input voltage and output current.

5. References

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[2] G. Fridman, G. Friedman, A. Gutsol, A. B. Shekhter, V. N. Vasilets, and A. Fridman: Plasma Process. Polym. **5** (2008) 503–533.