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Spatial and Temporal Analysis of Microplasma Light Emission
大気圧マイクロプラズマの時空間発光分析

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Microplasma was analyzed by emission spectroscopy method. Microscope photos of the discharge were taken for various discharge gaps under 100 μm in order to observe the micro-discharge shape and streamer formation.
Emission spectrum showed peaks of N_2 second positive band system (N_2 SPS), N_2 first negative band system (N_2^+ FNS), N_2 first positive band system (N_2 FPS), OH and Ar I for the discharge in N_2, Ar and N_2/Ar.

1. Introduction

Microplasma proved to be an efficient and economical solution for a series of applications such as NOx removal, indoor air treatment, sterilization of bacteria or surface treatment of polymers [1], [2]. Moreover among nonthermal plasma technologies microplasma has advantages due to its small size of reactor and power supply. Our microplasma is a dielectric barrier discharge at atmospheric pressure.

It is still necessary that some of the fundamental aspect of microplasma physics to be studied in order to develop and optimize the application processes. Emission spectroscopy is one of the methods for plasma analysis [3].

2. Experimental Setup

Emission spectra were measured by an ICCD camera (Ryoushi-giken, SMCP–ICCD 1024 HAM-NDS/UV) and a spectrometer to which was attached a fiber optic. Photos of microdischarges were taken using a microscope (Olympus, BH) and a digital camera (Olympus, E-620). A fiber optic was used in order to have an accurate measurement of a small part of the microplasma discharge. Self made fiber optics which diameters were about 8, 20 and 100 μm were employed. A negative pulse Marx Generator was used to energize the electrodes.). Experiments were carried out at atmospheric pressure in N_2, Ar, and N_2/Ar mixture. Discharge voltage was negative pulse, rise time 100 ns, width 1 μs at 1 kHz.

Microplasma electrodes are perforated metallic plates covered with a dielectric layer. Due to small discharge gaps (0~100 μm) and to the assumed specific dielectric constant of $\varepsilon r = 10^4$, a high intensity electric field (10^7 ~10^8 V/m) could be obtained with relatively low discharge voltages around 1 kV [1].

Microplasma was measured in different points along X axis by varying the position of the electrodes as shown in Fig. 1 (a) and (b). The spatial distribution of the light intensity was measured when the right electrode and left electrode were energized alternatively by the negative pulse power supply. The temporal distribution of the microplasma light emission was measured between the electrodes when the right electrode was energized by the negative pulse power supply (Fig. 1 (b)).

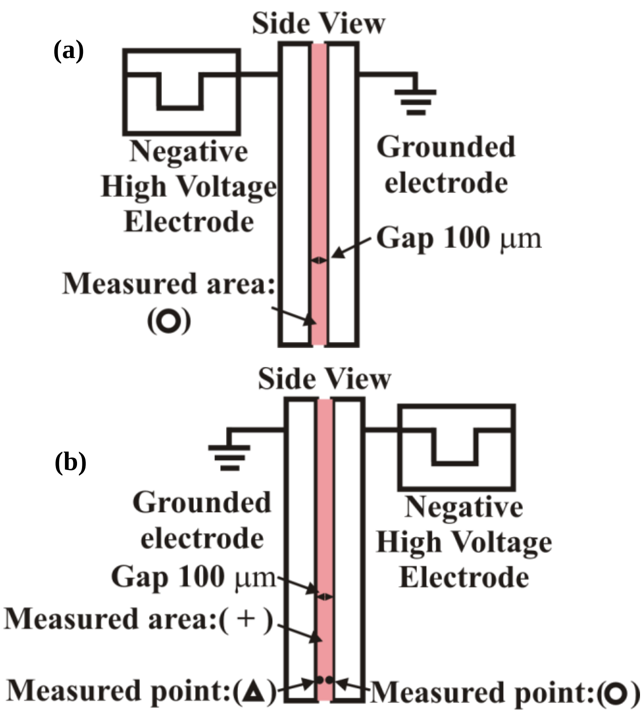

Fig.1. An experimental setup.

3. Spatial and Temporal Distribution of Microplasma Light Emission

The light emission from a microdischarge in 100 µm discharge gap is shown in Fig. 2. It has a wider area towards the negative electrode and a smaller and more intense area towards the grounded or the positive one [4]. Streamer diameter was observed about 10 µm, and was thinner than previously reported [5].

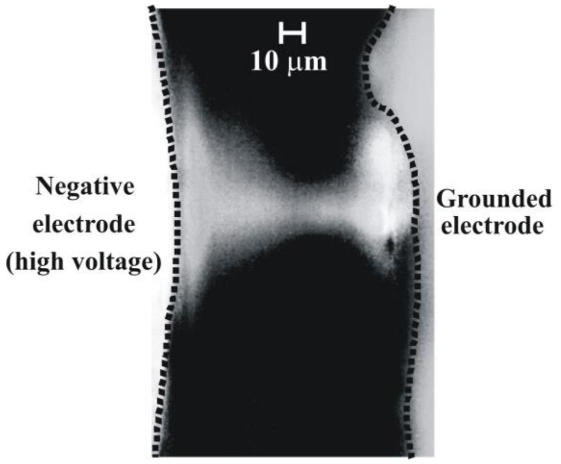

Fig.2. Photograph of a microdischarghe for 100 µm discharge gap.

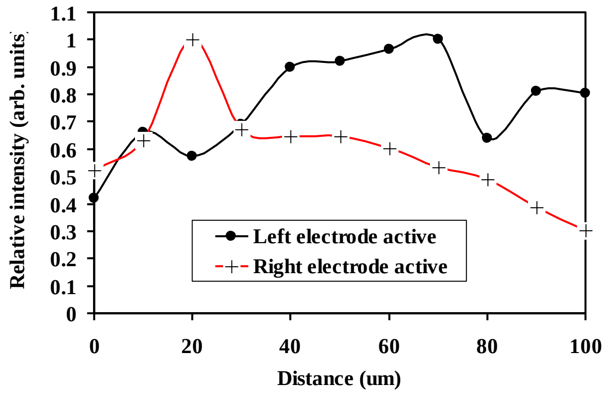

Fig.3. Spatial distribution of N_2 SPS peak at 337.1 nm in the discharge gap.

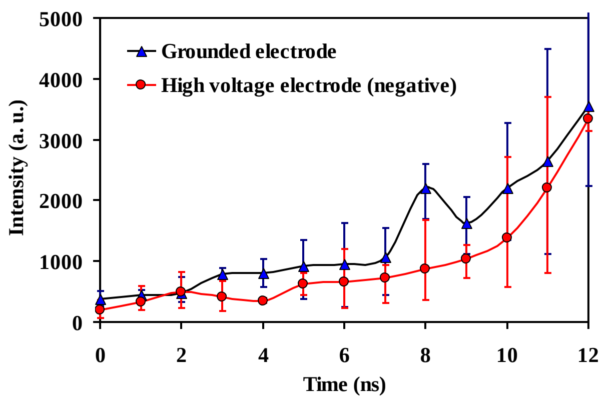

Fig.4. Temporal distribution of N_2 SPS peak at 337.1 nm in the discharge gap.

Emission spectrum showed peaks of N_2 second positive band system (N_2 SPS), N_2 first negative band system (N_2^+ FNS), N_2 first positive band system (N_2 FPS), OH and Ar I for the discharge in N_2, Ar and N_2/Ar mixture. The spectra was measured with a opening time of the ICCD camera shutter of 1 µs.

The relative intensities of the light emission corresponding to N_2 SPS peak at 337.1 nm are shown in Fig. 3 for both the left electrode active (Fig. 1 (a)) and right electrode active (Fig. 1 (b)). The emission intensities were measured for pure N_2 discharge. This is in agreement with T. Hoder et. al. [6] which measured the luminosity distribution of N_2 SPS peak at 337.1 nm for synthetic air DBD discharge and obtained a higher intensity towards anode.

Temporal distributions of the light emission for the N_2 SPS peak at 337.1 nm obtained for 1% N_2 in Ar discharge are shown in Figure 4. The measurement points were between the electrodes close to the high voltage electrode with negative polarity and near the grounded electrode (Fig. 1 (b)). The ICCD camera shutter was opened for about 15 ns from which rise time and fall time represented 12 ns thus it could be considered that the effective opening time was 3 ns. The time origin was considered to be at the beginning of the discharge current when the light emission measured with 90% sensitivity of the Micro Channel Plate from ICCD camera was not observed.

Near the negative electrode the light intensity was weaker compared to the measurement point near the grounded or positive one up to 10 ns. Similar results were reported by Kozlov et al [7] which stated that the ratio of the peak intensities I (cathode)/I (anode) for the spectral band N_2 C (0,0) is subunit up to about 6 ns.

References

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