Light emission of microdisharges in microplasma

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Introduction

Microplasma can be found in many applications. In the last years, the technology was used in applications such as NOx removal, surface treatment and sterilization or inactivation of bacteria.

The fundamental phenomena of microplasma discharge are not fully understood. The development and optimization of microplasma technologies depend on the clarification of microplasma physics. Our microplasma is a dielectric barrier discharge at atmospheric pressure.

Experimental Setup

(1)Microplasma Electrodes

The electrodes consist in perforated metallic plates covered with a dielectric layer.

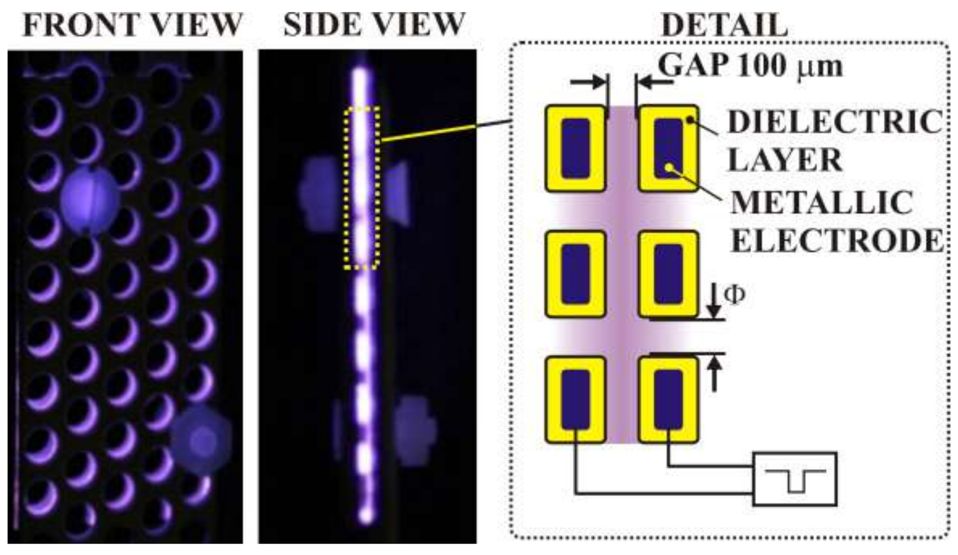

Fig. 1 Microplasma electrodes

Electrode size was 20 mm versus 40 mm for emission spectroscopy analysis. Discharge gap was set from 30 μm to 100 μm in this study.
A *Marx Generator* with MOSFET switches as pulse power supply:
- **Output Voltage: -2 kV negative**
- **Rise time: 100 ns**
- **Pulse width: 1 μs**

(2) Experimental setup

Emission spectrum was measured by a spectrometer, an ICCD camera and a photomultiplier tube. Photos of microdischarges were taken using a microscope and a digital camera.
Gas flow rate: Ar, N_2/Ar and O_2/Ar at 10 L/min.

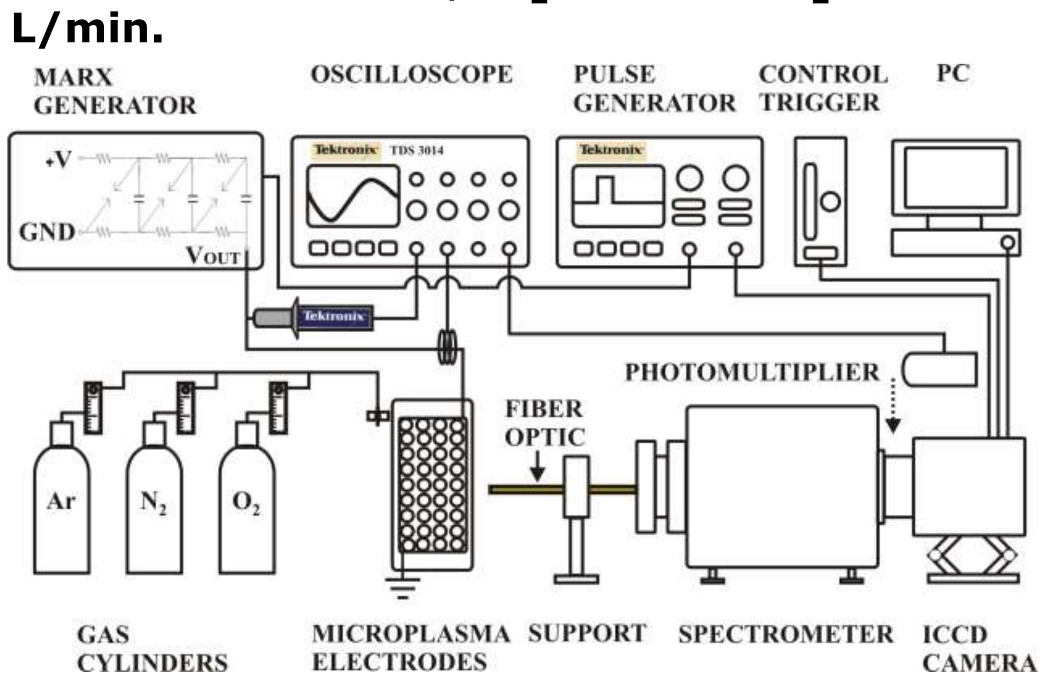

Fig. 2 Experimental setup.

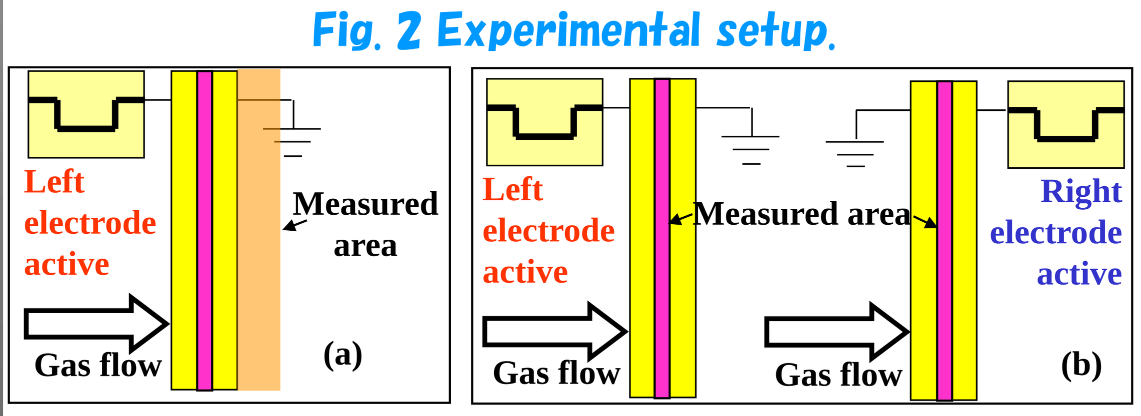

Fig. 3 Measured area of emission spectra: (a) outside the electrode; (b) in discharge gap.

(3) Electrical Characteristics

Very small discharge gaps and relatively *low discharge voltages* (about 1 kV)

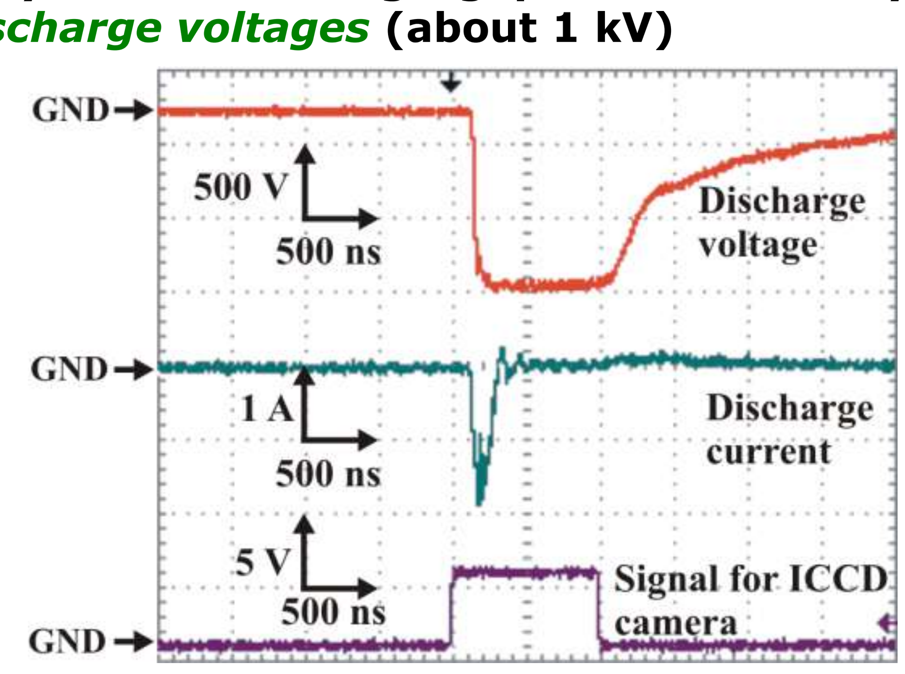

Fig. 4 Waveforms of the discharge voltage, corresponding discharge current and gate signal for ICCD camera.

A high intensity electric field (10^7-10^8 V/m) assures the formation of microplasma and a corresponding discharge current.

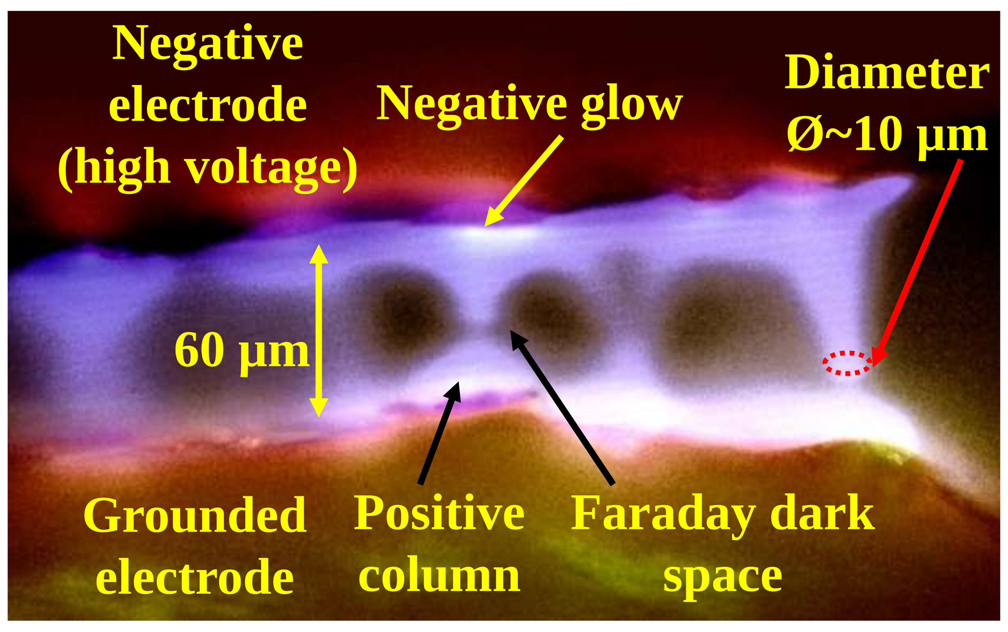

Fig. 5 Phenomena of microdischarges.

Emission Spectroscopy

Emission spectrum was measured with camera shutter opened for *1 μs*.

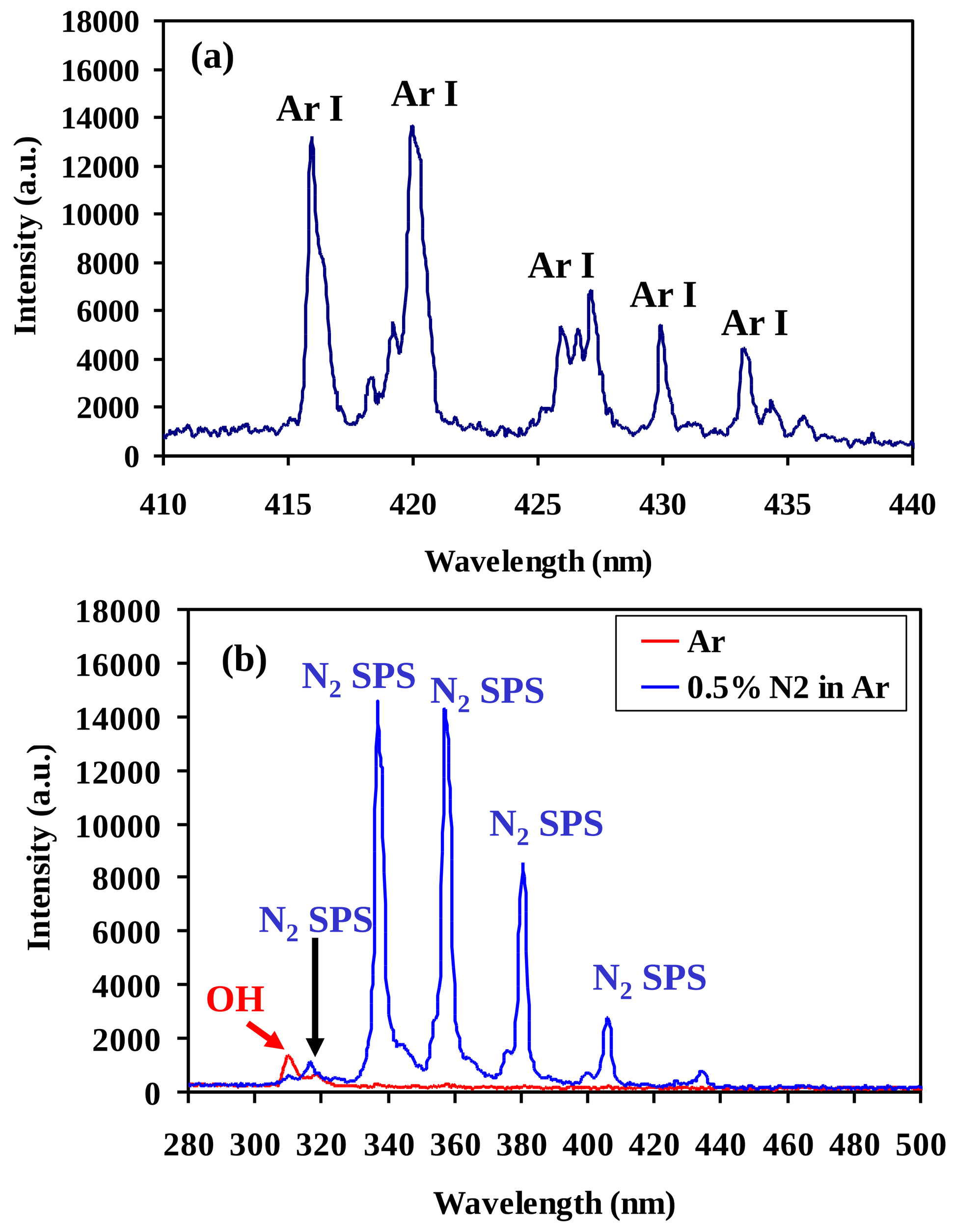

Fig. 6 Emission spectrum of microplasma in: (a) Ar; (b) N_2/Ar at -1.2 kV.

Emission spectrum in Ar and Ar/N_2 shows:
- ***N_2 second positive band system peaks* at 315.9, 337.1, 357.7, 380.4, 400 and 405 nm.**
- ***OH peaks* at 306.4, 307.8 and 308.9 nm.**
- ***Ar I peaks* were measured at 415.8, 419.1, 419.8, 420.1, 426.6, 427.2, 425.9, 433.3, 696.5, 706.7, 727.3, 738.3; 703.2, 750.4 and 772.4 nm.**

N_2 molecules excited argon neutrals and reaction in argon plasma with N_2 addition:
$Ar^* + N_2(X^1\Sigma_g^+)v=0 \rightarrow N_2(C^3\Pi_u)v'=0 + Ar$
Spontaneous radiation of formed excited state of nitrogen:
$N_2(C^3\Pi_u)v'=0 \rightarrow N_2(B^3\Pi_g)v''=0 + h\nu$

Spatial distribution outside of electrodes shows a distribution of about 1 mm for the OH peak at 309 nm and 500 μm for the Ar I peak at 696.54 nm respectively.

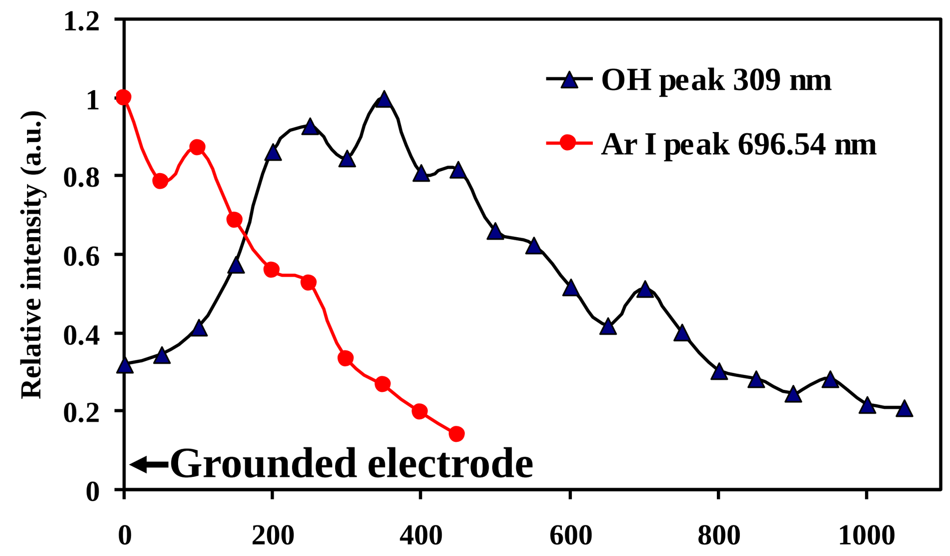

Fig. 7 Spatial distribution of OH radical and Ar I at the outside of grounded electrode for electrode arrangement shown in Fig. 3 (a).

The streamer diameter was proportionally with the discharge gap and thinner than previously reported. It has a wider area towards negative electrode and a smaller towards the grounded or positive one.

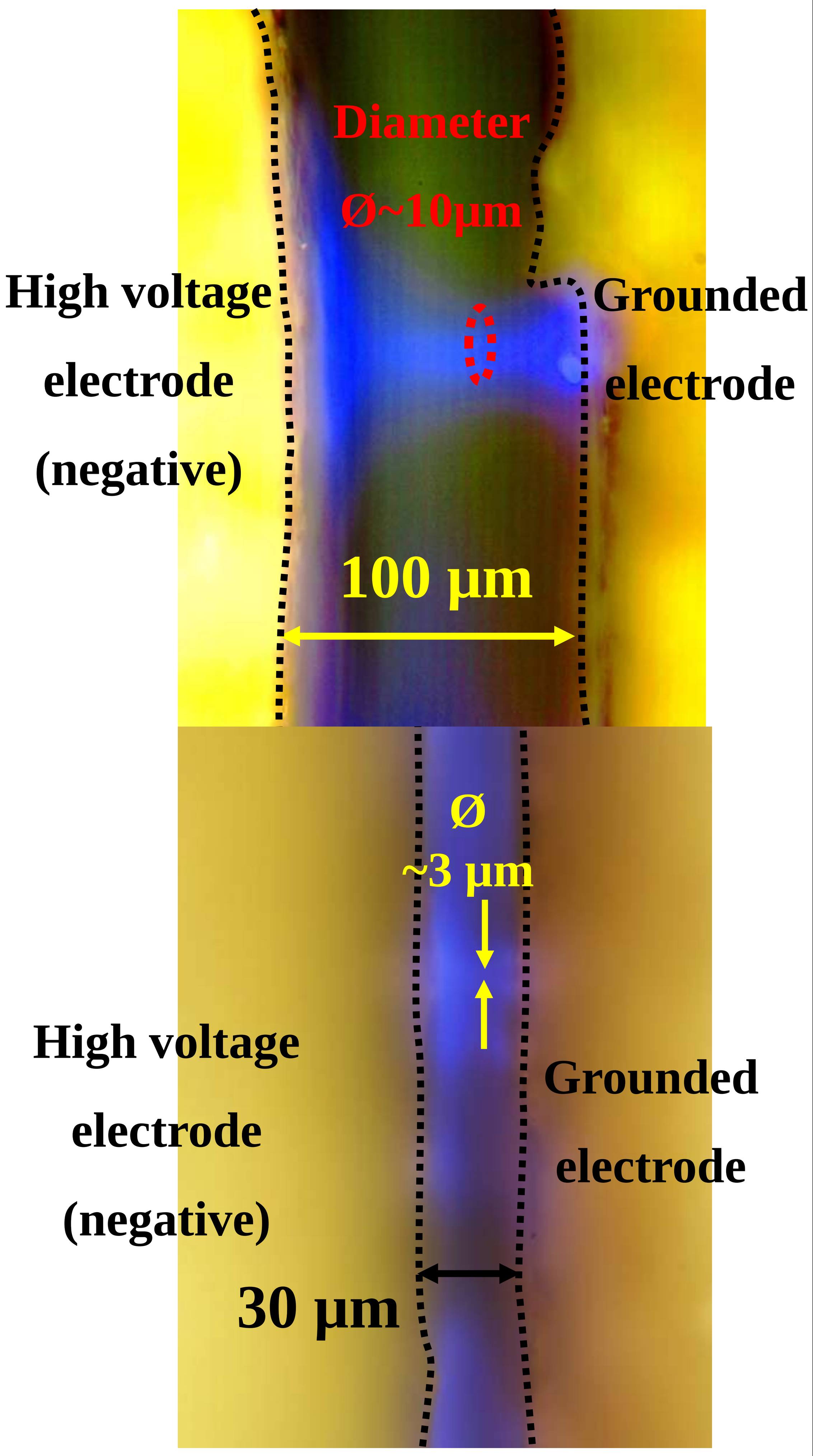

Fig. 8 Photo of a streamer from microplasma discharge.

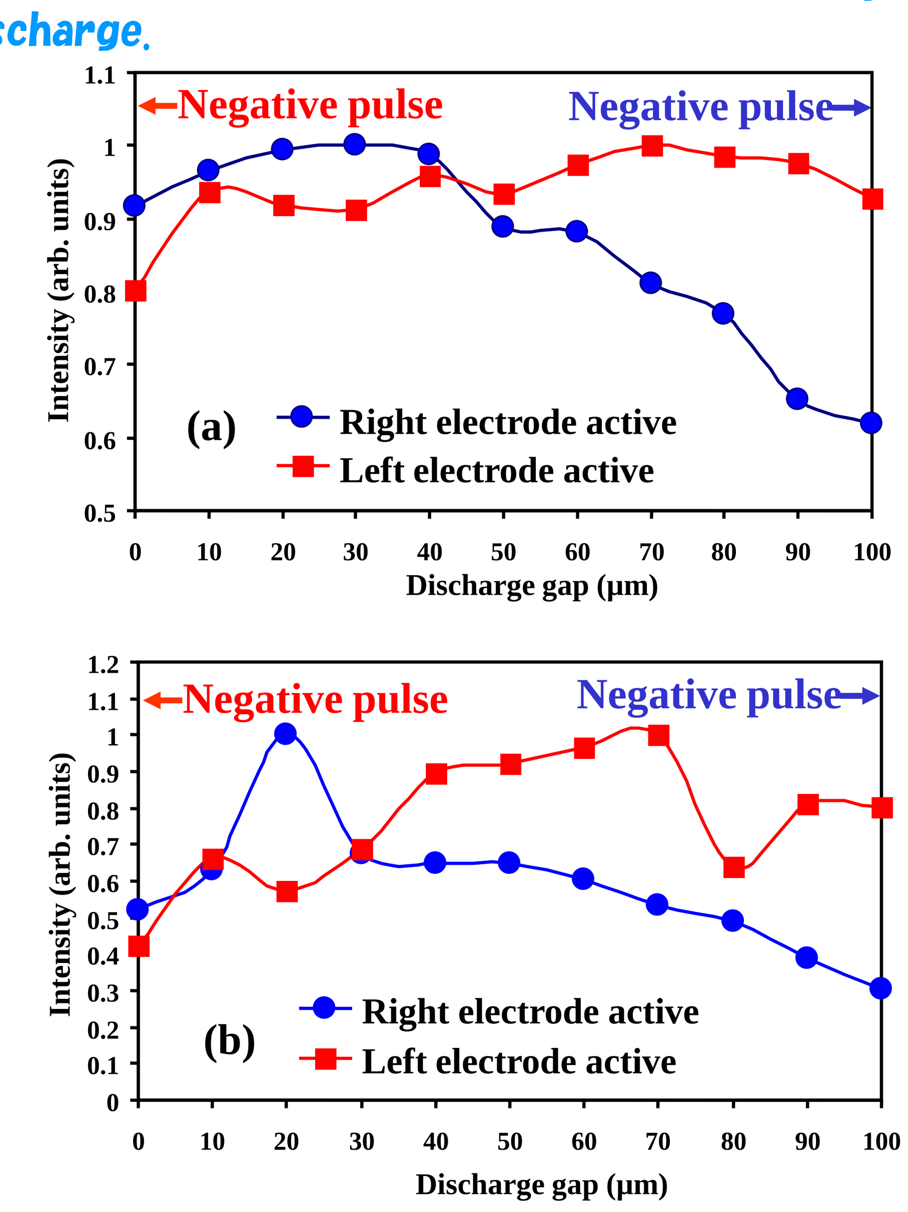

Fig. 9 Spatial distribution of N_2 SPS peak at 337.1 nm in the discharge gap as shown in Fig. 3 (b) for: (a) 5% N_2 in Ar; (b) pure N_2 discharge.

Spatial distribution inside the discharge gap shows a higher intensity towards the grounded electrode (anode). A more diffuse discharge for the 5% N_2 in Ar and higher fluctuations for N_2 discharge.

Conclusions

- **Emission spectrum of microplasma shown intensity peaks of *N_2 SPS, OH and ArI*.**
- **Spatial distribution of *ArI* peak at *696.54 nm* and *OH* peak at *309 nm* outside the grounded electrode was measured up to 500 μm for ArI peak and 1 mm for OH peak respectively.**
- **Streamer diameter was proportionally with the discharge gap.**
- **Spatial distribution of *N_2 SPS* peak at *337.1 nm* in the discharge gap shown a higher intensity near the grounded electrode (anode).**