Characteristics of Pulse Powered Microplasma in Small Discharge Gap

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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.

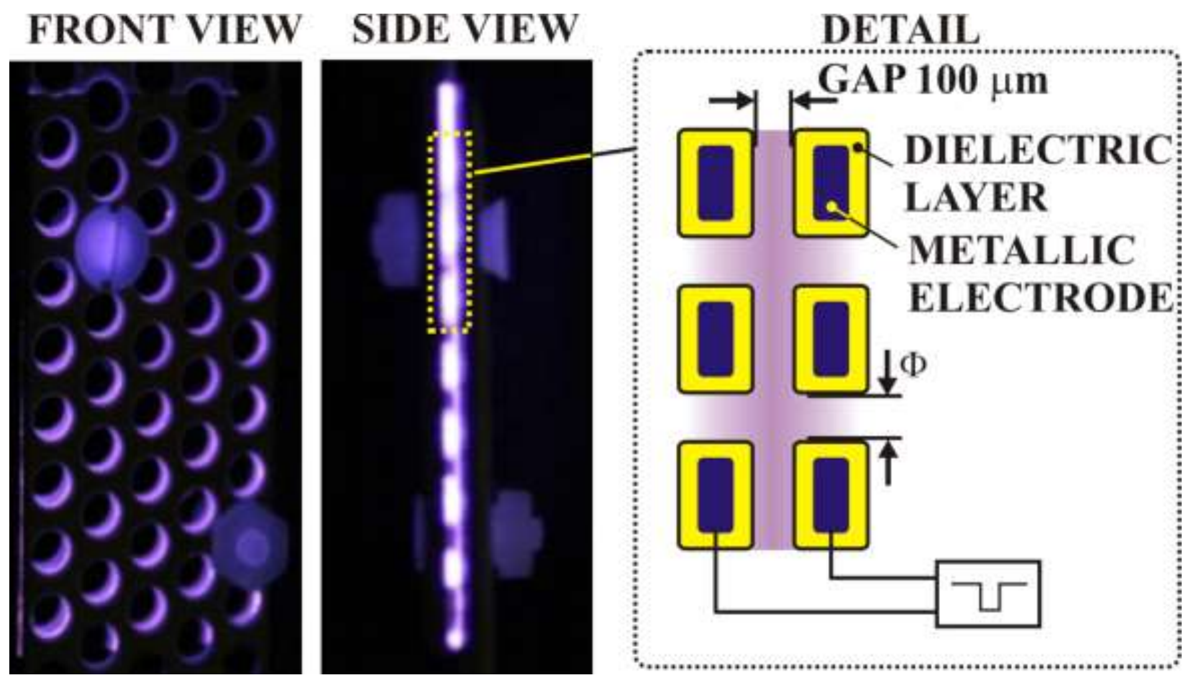


Fig. 1 Microplasma electrodes

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 and N_2/Ar at 10 L/min.

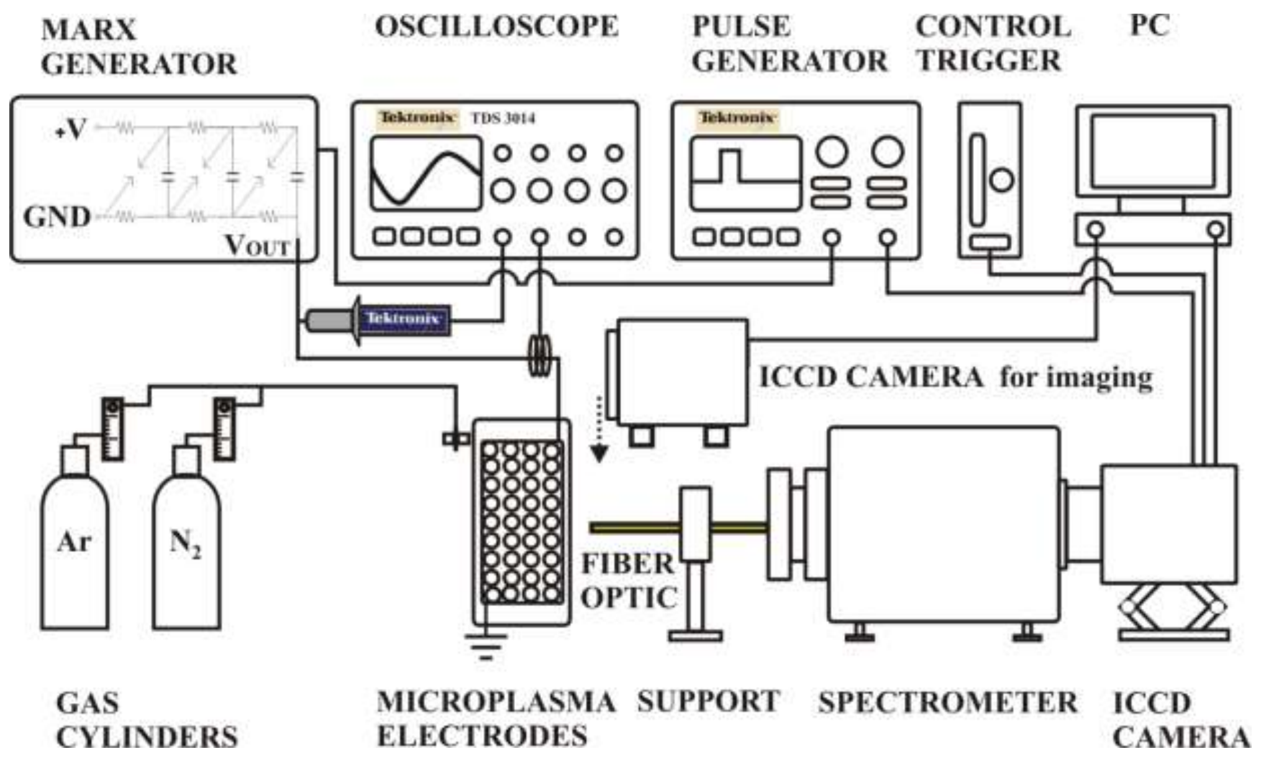


Fig. 2 Experimental setup.

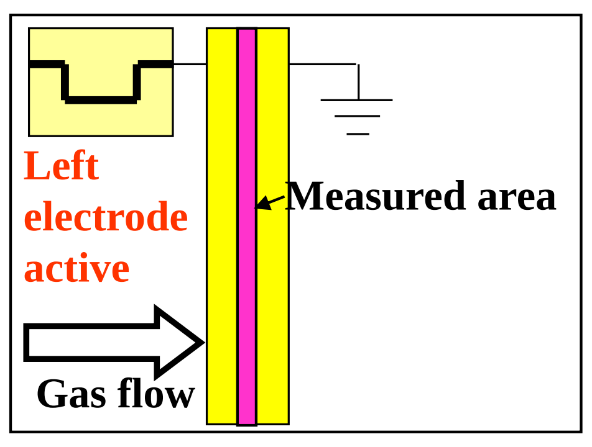


Fig. 3 Measured area of emission spectra.

(3) Microdischarges

Very small discharge gaps and relatively *low discharge voltages* (about 1 kV). A *high intensity electric field* (10^7-10^8 V/m) assures the formation of microplasma.

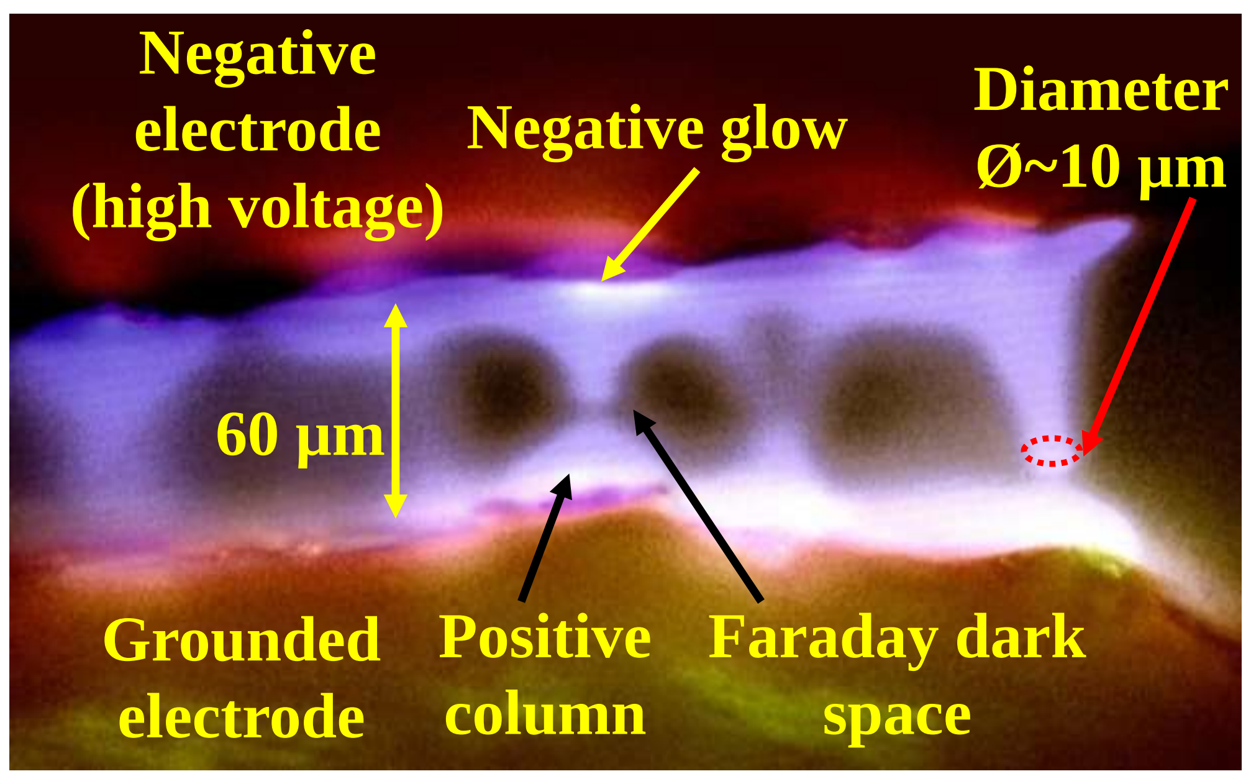


Fig. 4 Phenomena of microdischarges.

Emission Spectroscopy

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

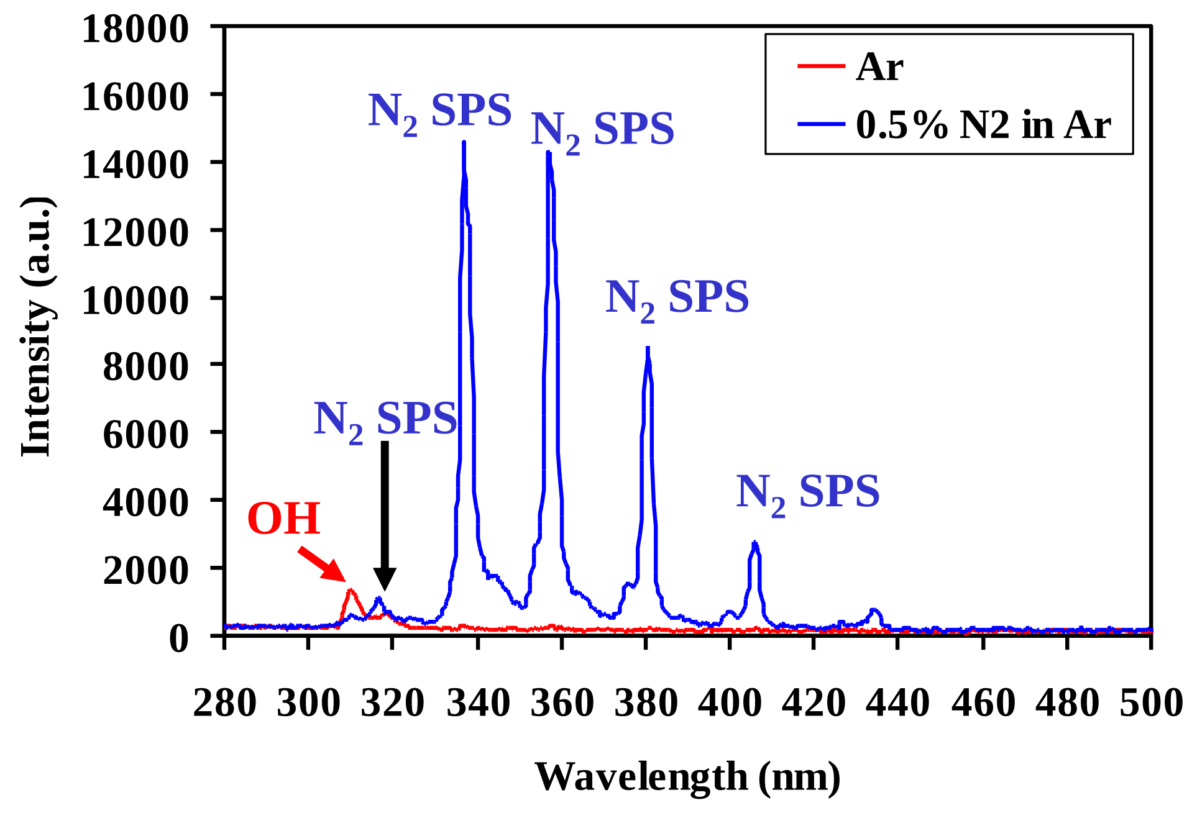


Fig. 5 Emission spectrum of microplasma in N_2/Ar at -1.2 kV.

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 and temporal distribution of Ar I peak at 696.5 nm and N_2 SPS peak at 337.1 nm shows higher intensity towards anode up to 20 ns and after that shifted to cathode.

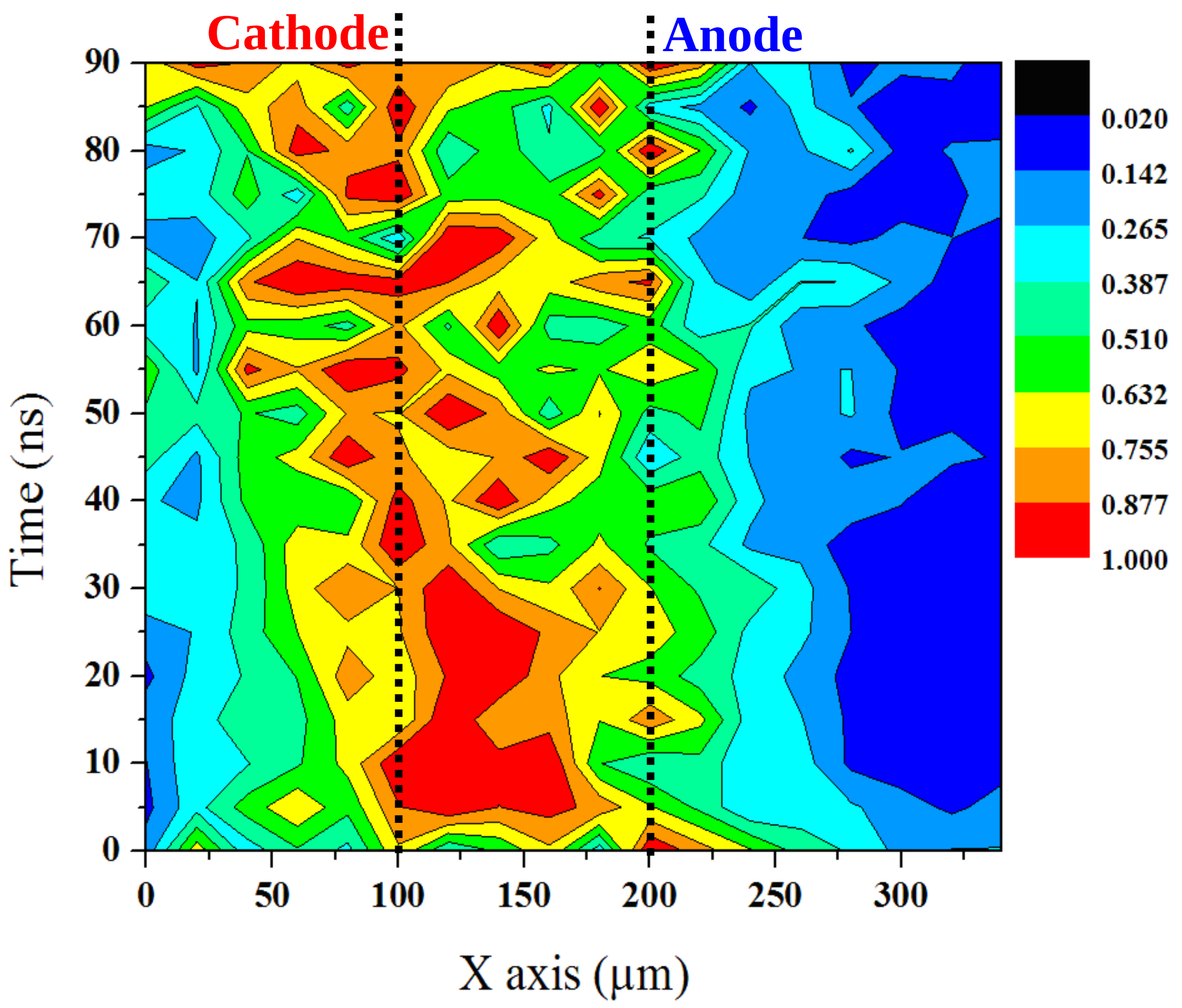


Fig. 6 Spatial and temporal evolution of the relative intensity of Ar I peak at 696.5 nm for microplasma discharge in Ar at 1 kV.

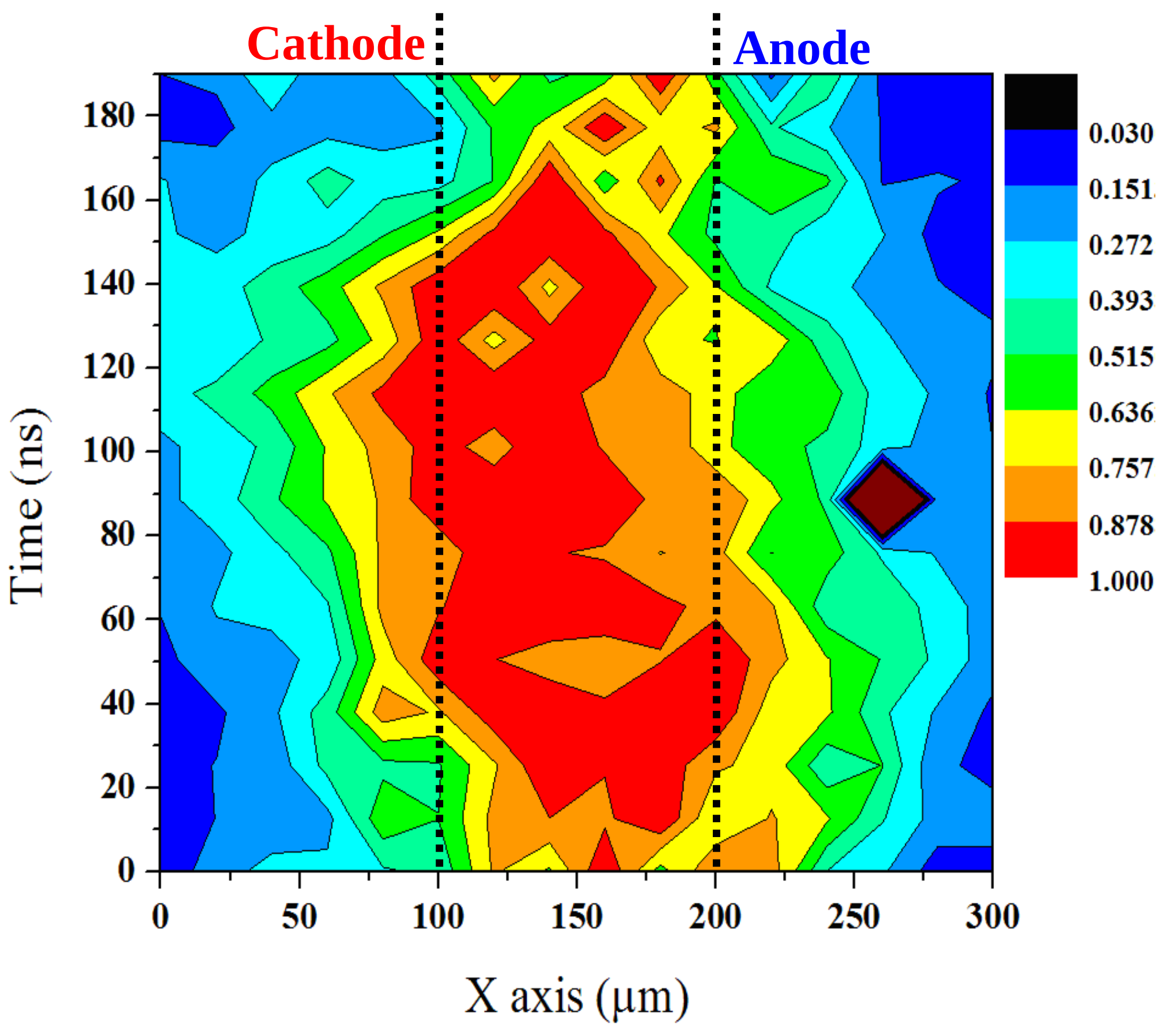
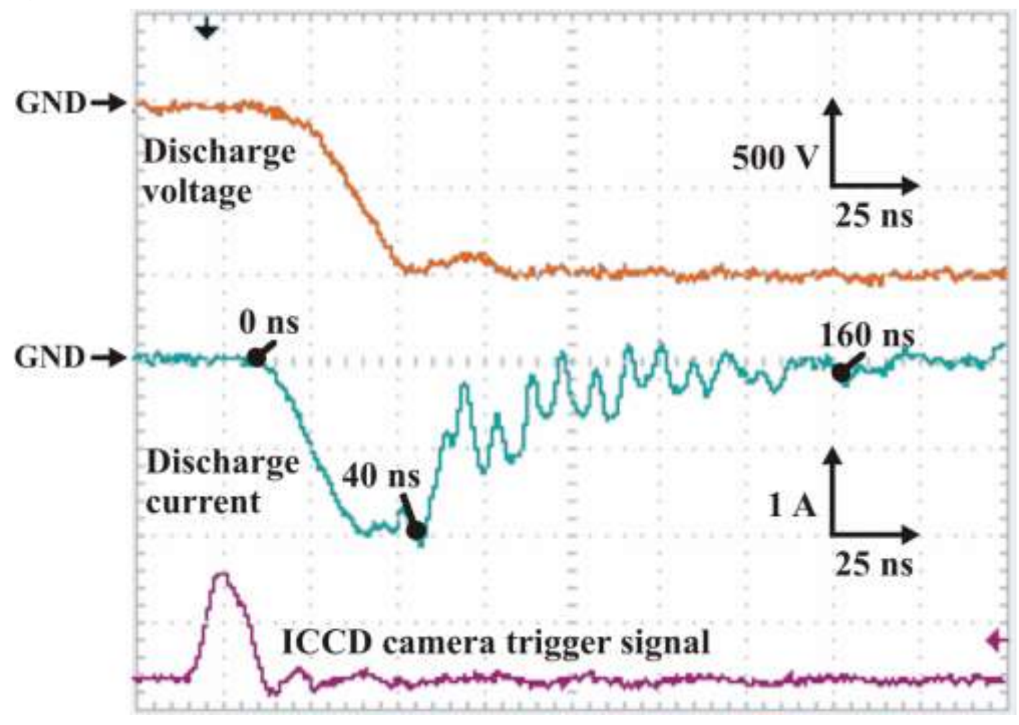


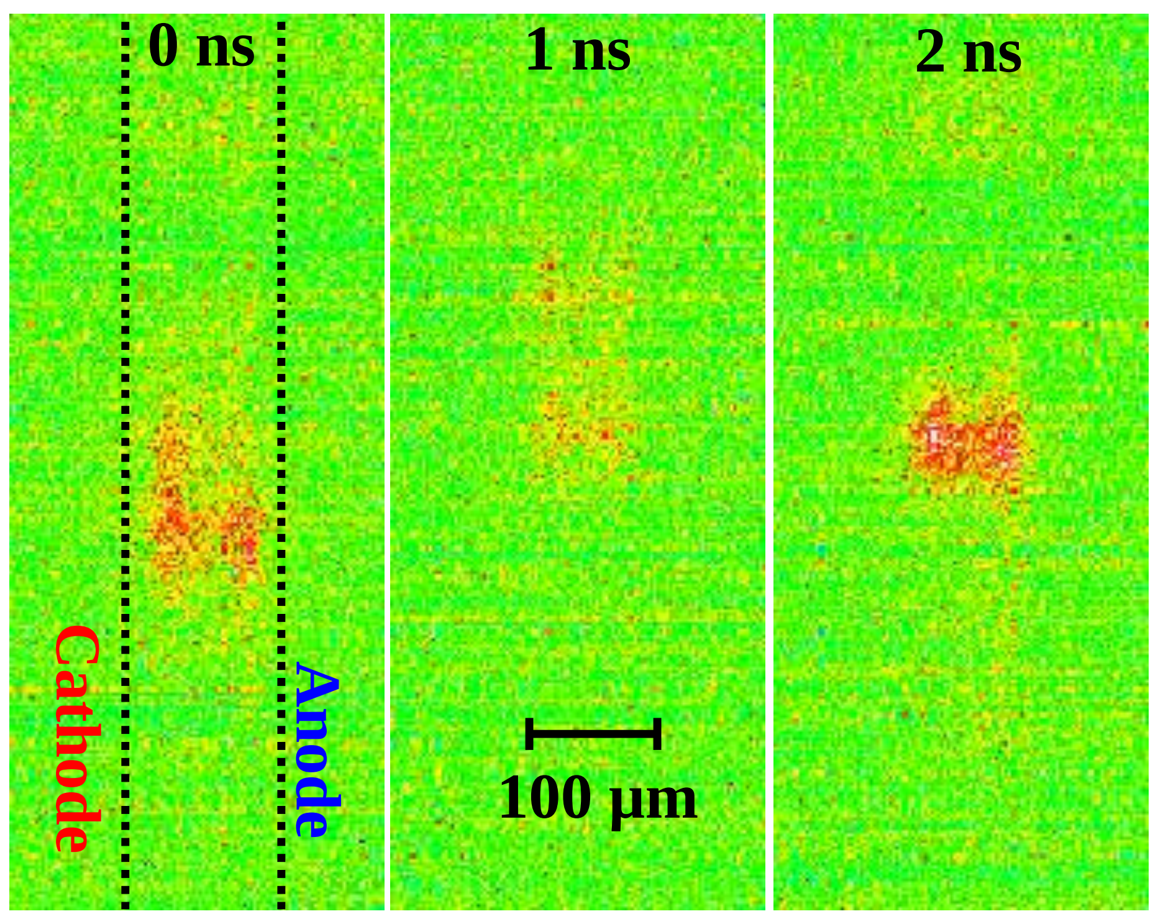
Fig. 7 Spatial and temporal evolution of the relative intensity of N_2 SPS peak at 337.1 nm for microplasma discharge in 1% N_2 in Ar at 1 kV.

Spatial and Temporal Evolution of Microplasma

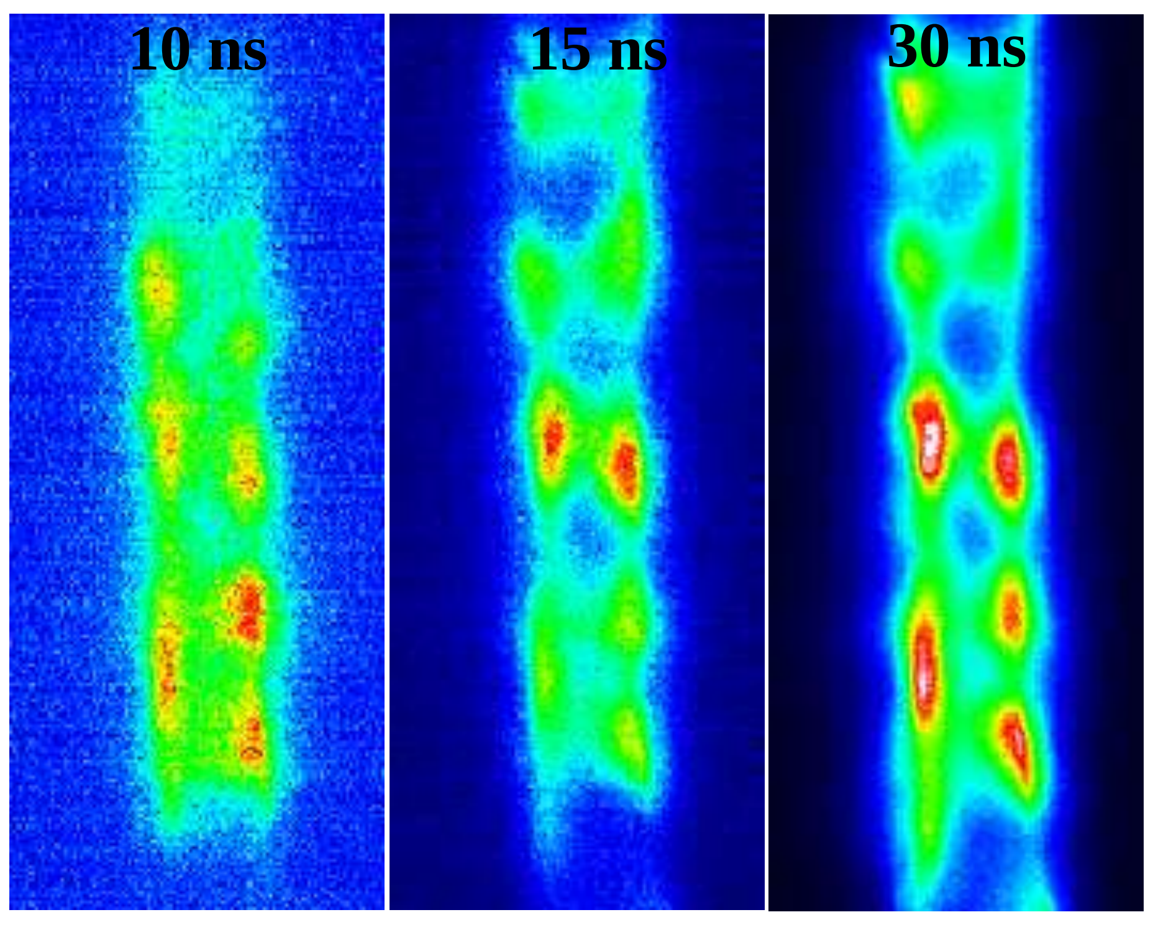
The observation of microdischarge by ICCD camera shows the streamer formation phenomena and the correlation of the microdischarge evolution with the discharge current.



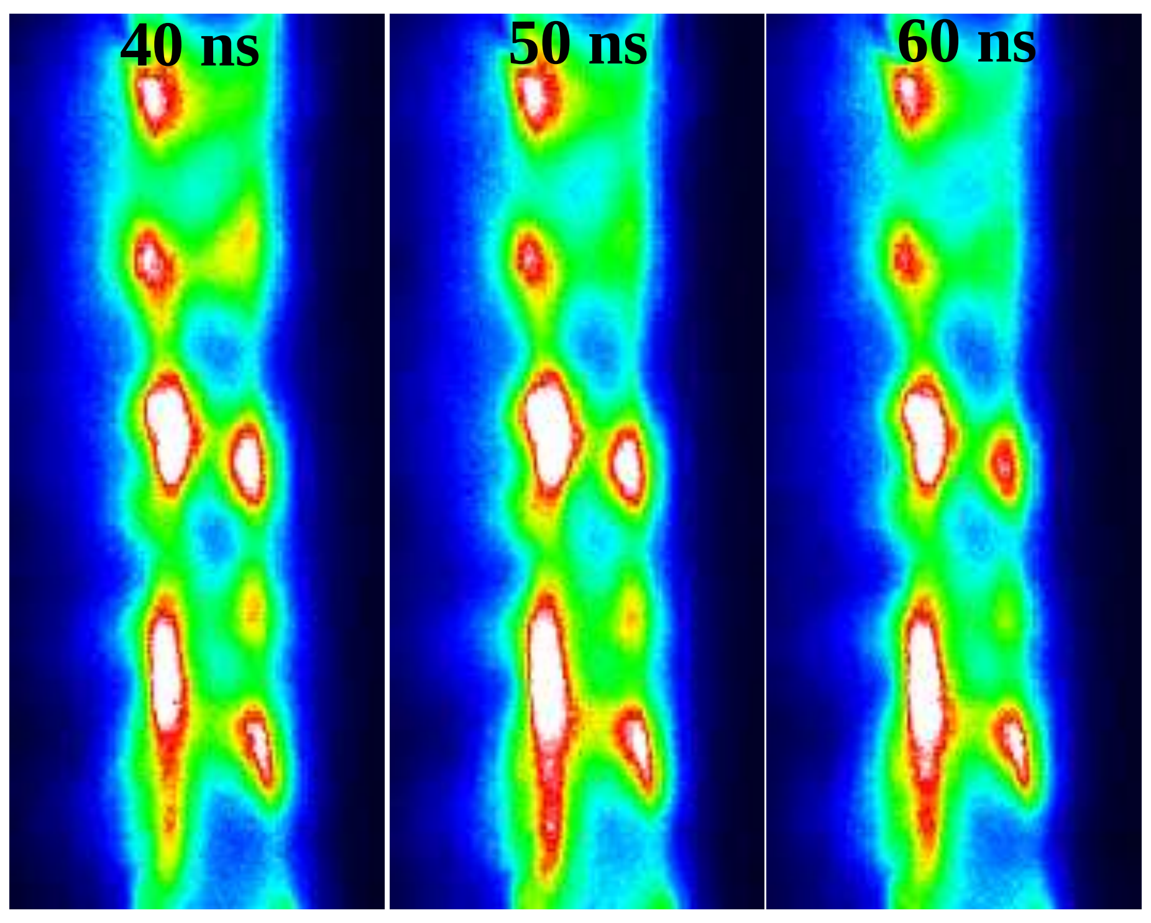
1) Streamer reaches cathode up to 1 ns



2) Cathode layer formation up to 30 ns



3) Cathode layer enhancement up to 70 ns



4) Cathode layer decay up to 270 ns

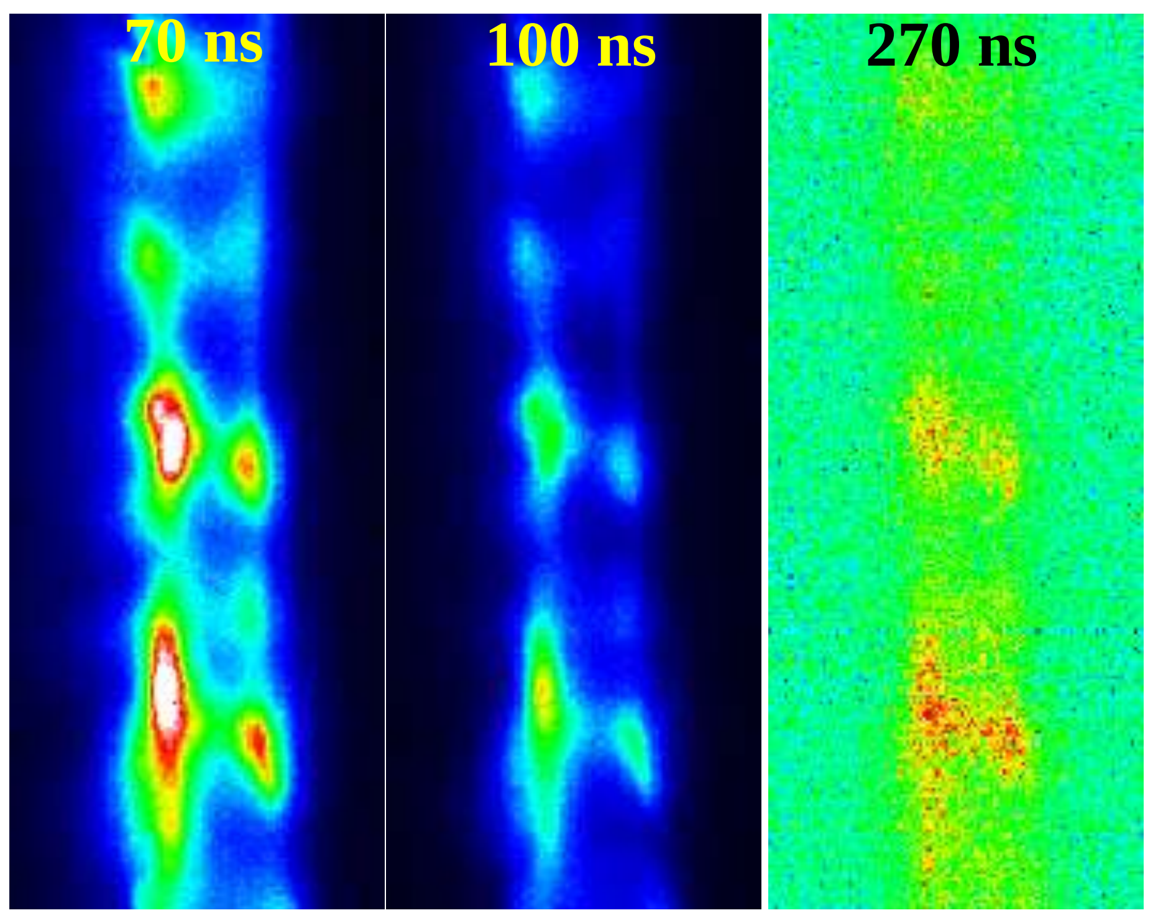


Fig. 8 Spatial and temporal evolution of microplasma discharge in 3% N_2 in Ar at 1 kV. ICCD camera shutter was opened for 2 ns.

Microdischarges phenomena was well correlated with the discharge current value.

Conclusions

- **Emission spectrum of microplasma shown intensity peaks of *N_2 SPS, OH and ArI*.**

- **Spatial and temporal evolution of the relative intensities of *ArI* peak at *696.54 nm* and *N_2 SPS* peak at *337.1 nm* showed higher intensity towards anode up to 20 ns and after it shifted towards cathode.**

- **ICCD camera images showed the evolution of microdischarges from the phase when streamer reaches anode to cathode layer formation, cathode layer enhancement and finally cathode layer decay.**