Pulsed Power Microplasma Diagnosis by Emission Spectroscopy

パルスパワーマイクロプラズマの発光スペクトル分析

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Introduction

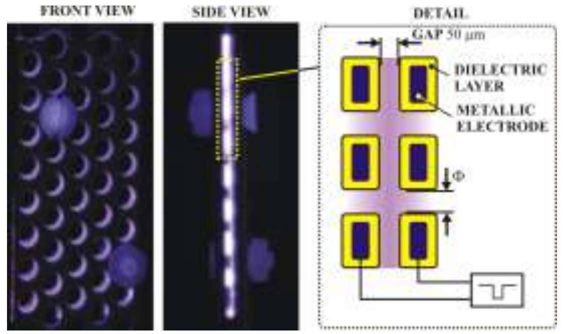
Microplasma can be found in many applications. The technology is used also for surface treatment and one of the discharge gases is argon. Although there is an interest for application driven research many of the microplasma phenomena are not fully understood. Emission spectroscopy is one of the methods to analyze plasma process .

Microplasma is atmospheric pressure nonthermal plasma. The aim of this paper is to analyze the emission spectrum of the microplasma in argon gas.

Experimental Setup

(1) Microplasma Electrodes

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



Microplasma electrodes

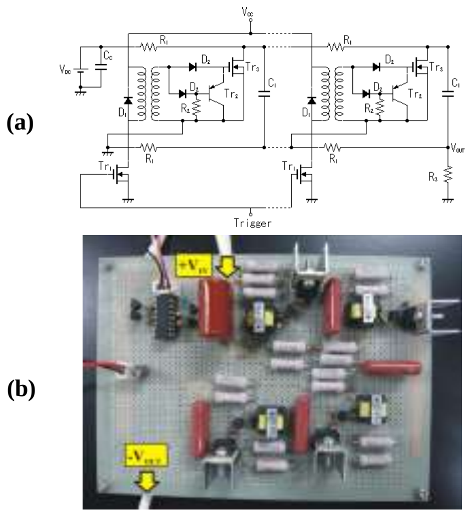
Electrode size was 20 mm versus 40 mm. Discharge gap was set at 50 μm in this study.

Emission spectra of microplasma discharge was observed from the side part of electrodes.

(2) Marx Generator

Capacitors are charged in parallel connection at voltage *V*.

⇨ When the MOSFET are turned on the capacitors are discharge in series connection with an output voltage *V multiplied with the number of capacitors*.



Marx Generator (a) circuit of Marx Generator, (b) photo of Marx Generator.

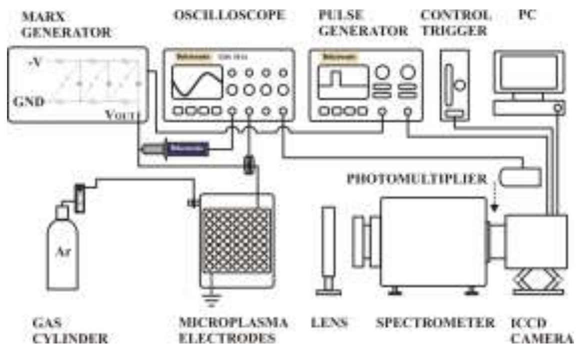
Marx Generator with MOSFET switches:

- Negative pulses up to -1.8 kV
- Frequency 1-24 kHz
- Pulse width 500 ns
- Rise time 80 ns

(3) Experimental Setup

Emission spectrum was measured by a spectrometer, an ICCD camera and a photomultiplier tube. The ICCD camera was triggered by a pulse generator.

Gas flow rate: *Argon with purity 99.999% at 5 L/min.*

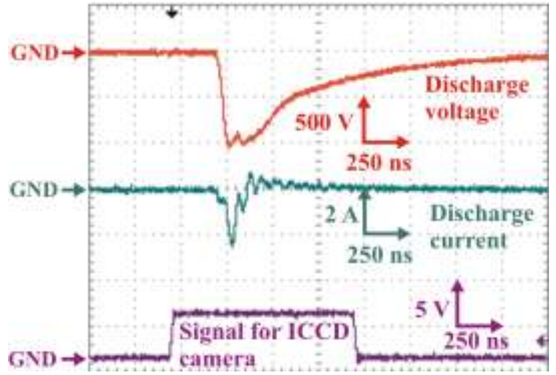


Experimental setup

Emission Spectrum

Very small discharge gaps and low discharge voltages (around 1 kV):

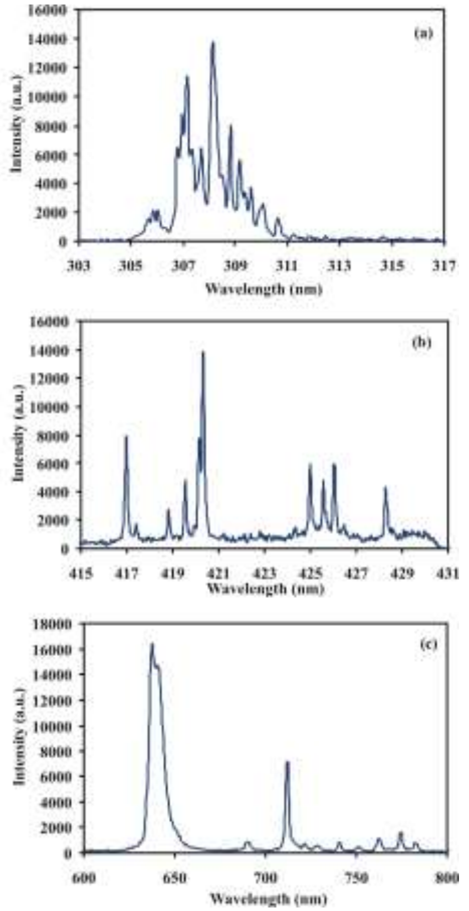
⇨ A high intensity electric field (10^7 – 10^8 V/m) assures the formation of microplasma and a corresponding discharge current.



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

Emission spectrum in Argon shows:

- High intensity peaks *between 305 nm and 310 nm*
- In red region a high intensity peak at *641 nm*



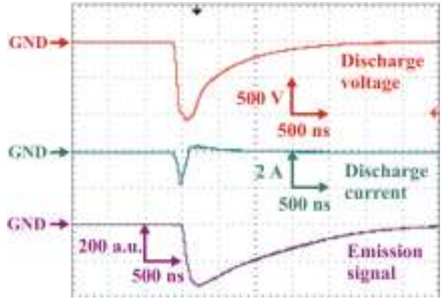
Emission spectrum in dry Argon at 1 kV (a), UV region (b), violet region (c), red region.

Although discharge gas was DRY Argon with purity 99.999%:

⇨ Peaks *between 305 and 310 nm* could be attributed to *OH radical*:

- *due to the humidity on the reactor walls*
- *due to the dielectric layer on the electrodes*

Lifetime emission signal corresponding to the wavelength of *308 nm* was around *3 μs*.



Waveforms of the discharge voltage, discharge current and emission signal of microplasma discharge (308 nm) in Argon.

Conclusions

① Emission spectrum shows wavelengths of Argon in the *ultraviolet, violet and red regions* of the spectrum with pulsed power microplasma.

② Lifetime of emission signal measured by a photomultiplier tube corresponding to the wavelength of *308 nm* was about *3 μs*.

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