Dielectric barrier discharge microplasma in small discharge gaps

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Introduction

Microplasmas 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.

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

(2) Emission Spectroscopy

Emission spectrum was measured with 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 N₂/Ar at 10 L/min.

(3) Microparticles

Very small discharge gaps and relatively low discharge voltages (about 1 kV). A high intensity electric field (10⁶-10⁷ V/m) assures the formation of microplasmas.

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.

Microdischarges phenomena was well correlated with the discharge current value.

J=5.2 A/cm² for 830 µm microdischarge n=3/(ε₀E₀) = electron density vₐ = electron drift velocity = 2x10⁶ m/s E = intensity of electric field=1 kV/100 µm μₑ=νₑ/E = electron mobility=200 cm²/(V s) ρₑ = 1.6 x 10⁻⁶ cm²

Conclusions

• Emission spectrum of microplasma shown intensity peaks of N₂ SPS, OH and Ar.
• Spatial and temporal evolution of the relative intensities of Ar I peak at 696.5 nm and N₂ SPS peak at 337.1 nm showed higher intensity towards anode up to 20 ns and after that shifted to 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.