Introduction

Microplasma can be found in many applications. In the last years, the technology was used also for biomedical applications. Although there is an interest for application driven research, microplasma phenomena are not fully understood.

About microplasma

Microplasma electrodes are metallic electrodes covered with a dielectric layer. Small discharge gaps (0–100 μm) and assumed specific dielectric constant of ε = 108

• a high intensity electric field (106 – 108 V/m) around 1 kV.

Electrode size was 20 mm versus 40 mm. Electrode has holes to flow for gas, which diameter is ∅ 2 mm and its aperture ratio of 36%. Discharge gap was set at 50 μm.

Inactivation of bacteria by microplasma using carrier gas air or nitrogen containing water droplets

Experimental setup

Emission spectra were measured by an ICCD camera, a spectrometer and by a photomultiplier tube. A pulse generator was used to trigger the Marx Generator and the ICCD camera.

Compositions of gases used in experiments were N2 with water droplets and air with water droplets. Experiments were carried out in atmospheric pressure and the gas flow rate was set at 5 L/min. Water droplets were added in the carrier gas using a medical nebulizer.

Emission spectrum of microplasma

Emission spectrum of the microplasma discharge was measured in N2 gas, N2 gas with water droplets, air and air with water droplets.

Spectrum was obtained at discharge voltage -1.4 kV, rise time of 80 ns, pulse width of 500 ns, and discharge frequency of 1 kHz.

List of detected systems and peaks for the microplasma in N2 gas with water droplets

<table>
<thead>
<tr>
<th>Species (systems)</th>
<th>Transition</th>
<th>Peak Position (nm)</th>
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</thead>
<tbody>
<tr>
<td>N2 second positive</td>
<td>C(II) → B(II)</td>
<td>315; 337; 357.7; 375.5; 380.5; 400.0</td>
</tr>
<tr>
<td>N2 first negative</td>
<td>B(II) → X(II)</td>
<td>342.8</td>
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Excitation of nitrogen molecules in the ground state by direct electron impact and spontaneous radiation of formed excited state of nitrogen:

• the lifetime of photomultiplier signal of N2 SPS was about 40 ns

Waveforms of discharge voltage, discharge current and emission signal of microplasma (N2 SPS 337.1 nm) in N2 with water droplets.

Active radical species have etching effect to break the bacterial cell wall, and UV affects DNA directly to cut their structure.

Images of B. subtilis by SEM a) Living B. subtilis (x 10000); b) Sterilized B. subtilis by nitrogen plasma (x10000).

Conclusion

1) Analysis of emission spectrum shows:

• N2 SPS, N2 FNS, OH 3064 – A system and H2v band system for the microplasma discharge in N2 gas with water droplets

• N2 SPS, N2 FNS, and H2v band system for microplasma discharge in air with water droplets with lower intensities compared with emission spectrum of microplasma discharge in N2 with water droplets due to the quenching effect of oxygen atom and ozone.

2) Lifetime of emission signal measured by a photomultiplier tube corresponding to wavelength 337.1 nm of N2 SPS was about 40 ns.