Pulsed Power Microplasma Diagnostics for Glass’ Surface Treatment
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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. Emission spectroscopy is one of the methods to analyze plasma process and will allow the calculation of microplasma’s electron, vibrational and rotational temperatures. The aim of this research is to analyze microplasma by emission spectroscopy for the process of glass surface treatment. Other research groups investigated nonthermal plasma for surface treatment with similar characteristics such as high electron, and low rotational temperatures which recommends that this technology could be applied for the surface modification due to its low gas temperature and molecular excitation ability. Our microplasma has this characteristics obtained at relatively low discharge voltages around 1 kV which can be advantageous in furthermore implementing the technology in industry. Moreover the surface potential after the microplasma treatment is low (about 20 V) comparing with plasma jet that charges the surface at more than 200 V.

Experimental Setup
(1) Microplasma Electrodes
The electrodes consist in perforated metallic plates covered with a dielectric layer.

(2) Power Supplies
Marx Generator with MOSFET switches:
- Output Voltage: 2 kV negative
- Rise time: 100 ns
- Pulse width: 1 μs
- Frequency: 1-24 kHz

Neon transformer:
- Output voltage: up to 2 kV AC
- Frequency 24 kHz

Experimental setup:
A neon transformer was used to energize the electrodes at 1.3 kV. With the increase of treatment time the contact angle is decreasing from 41.5° without treatment to 8.5° after 30 seconds.

Surface Treatment of Glass
A neon transformer was used to energize the electrodes at 1.3 kV. With the increase of treatment time the contact angle is decreasing from 41.5° without treatment to 8.5° after 30 seconds.

Conclusions
• Emission spectrum of microplasma shown intensity peaks of N2 SPS, FNS, OH and Ar1.
• Lifetime emission signal peak of N2 SPS peak at 337.1 nm increased from 60 ns to about 500 ns when 1% N2 was added in Ar.
• Vibrational temperature $T_{vib}=3160$ K.
• Electron temperature $T_e=23000$ K.
• Rotational temperature $T_{rot}=300$ K.
• Microplasma=Nonthermal plasma

Photo of negative pulse Marx Generator.

Contact angle of a water droplet at the surface of glass before and after microplasma treatment.

For the treatment, a neon transformer was used to energize the electrodes at 1.3 kV. With the increase of treatment time the contact angle is decreasing from 41.5° without treatment to 8.5° after 30 seconds.

Microplasma electrodes
Electrode size was 20 mm versus 40 mm for emission spectroscopy analysis. Discharge gap was set at 50 μm in this study. Microplasma electrodes for surface treatment have 40 mm diameter.

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

(a) Marx Generator: (b) Neon transformer.

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

N2 molecules excited argon neutrals and reaction in argon plasma with N2 addition: $Ar^+ + N_2(eV) \rightarrow N_2^*(eV) + Ar$

Spontaneous radiation of formed excited state of nitrogen: $N_2^*(eV) \rightarrow N_2(bV) \rightarrow N_2 + hv$

Waveform of the discharge voltage, discharge current and emission signal of microplasma discharge in 1% N2 in Ar and in N2.

Lifetime emission signal of N2 SPS peak at 337.1 nm increased from 60 ns to about 500 ns when 1% N2 was added in Ar.

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