THE OBTAINING AND PROPERTIES INVESTIGATION OF PLASMA FORMATION AT PULSE DISCHARGE IN WATER AEROSOL

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The results of investigation of electro-physical and spectral properties of the impulse discharge plasma in aerosol were represented in work. The discharge current, voltage and integral spectrum of plasma were measured. The discharge space was filmed with the help of digital camera. The plasmoids with lifetimes about 150 milliseconds in the autonomous stage after current zero were observed.

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INTRODUCTION

Study of the pulse discharge in various environments is the one of the priorities research in modern plasmachemistry. One of these systems is pulsed discharge in water aerosols. Impulse discharge in water aerosol is often observed in experiments with electric discharge on air-liquid border due to dispersion of liquid drops [1, 2]. Other applications of aerosol discharge are fuel efficiency improvement and natural long-life plasmoid research. The observation of this phenomenon suggests the existence of a mechanism of energy storage in aerosol drops during discharge. This type of discharge is promising for use in the process of fuel reforming to improve combustion efficiency.

1. EXPERIMENTAL SET-UP FOR AEROSOL GENERATION

Aerosol source consists of fluoroplastic cylindrical vessel filled with water, a piezoceramic emitter connected to ultrasonic generator and an air compressor. The vessel is covered by plastic lid with a cone-shaped air nozzle in the centre. The vibrations of the emitter are causing creation of a water fountain under the nozzle from which the small water drops are scattered into the air and form aerosol. The air flow is blowing out aerosol through the nozzle to the discharge area (Fig. 1).

The discharge is caused by reservoir capacitor charged with a high-voltage generator. Between a capacitor and narrow copper electrodes was an air gap. Two different capacitors were used: one with capacity 15 nF charged to 19.5 kV and one with 2 mkF charged to 14 kV, which resulted in ~ 3 and ~ 200 J of stored energy respectfully.

The discharge current was measured by a Rogowski loop. The current and voltage were measured by digital oscilloscope (Metrix MTX1054). The discharge area was filmed with a digital camera with frame rate of 30 frames-per-second.

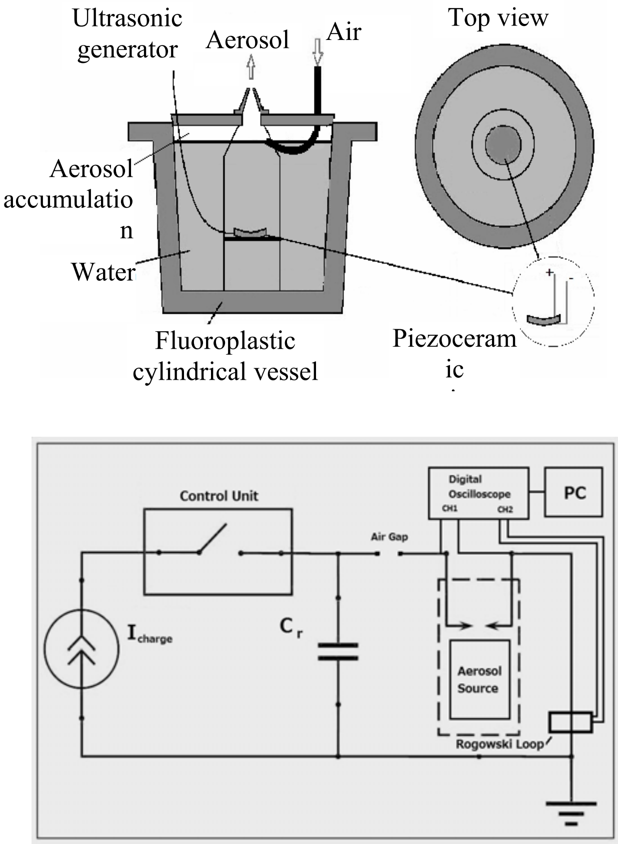

Fig. 1. Scheme of experimental setup

2. RESULTS AND DISCUSSIONS

Oscillograms of current and optical emission signal at different values of the air flow are shown on Figs. 2-4. Voltage of PEM (photo-electron multiplier) was 600 V, voltage supplied from the generator 19 kV, C = 15 nF.

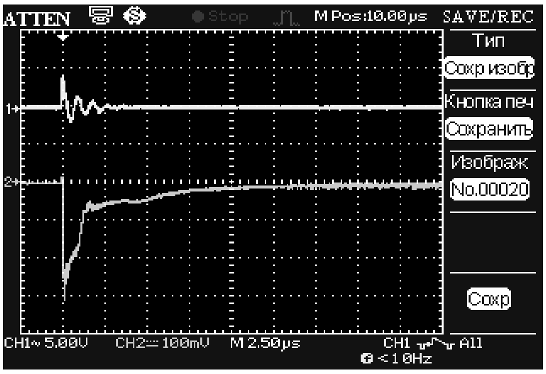

Fig. 2. Oscillograms of current (upper curve) and optical emission signal (lower curve) of discharge. Ugen = 19 kV, C = 15 nF. Air = 55 cm³/s

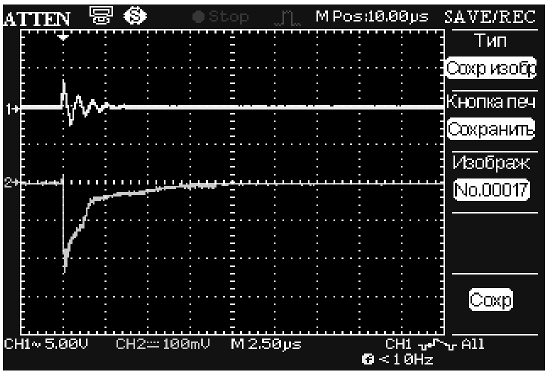

Fig. 3. Oscillograms of current (upper curve) and optical emission signal (lower curve) of discharge. Ugen = 19 kV, C = 15 nF. Air = 80 cm³/s

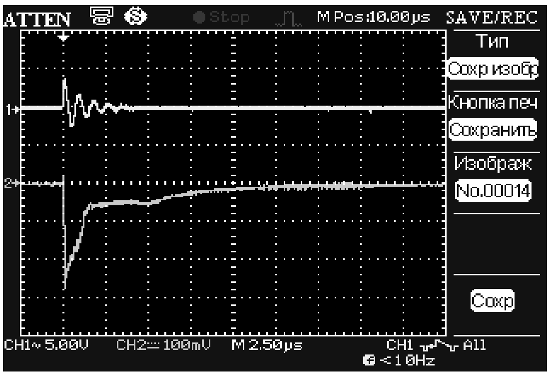

Fig. 4. Oscillograms of current (upper curve) and optical emission signal (lower curve) of discharge. Ugen = 19 kV, C = 15 nF. Air = 110 cm³/s

From these oscillograms, it was determined that in the discharge area the glow present during the time that 3...4 times longer that discharge time (time course of the discharge current).

Measurements of the discharge voltage and discharge current for two capacitors C_r – 15 nF, 2 mkF, with voltages 19.5 and 14 kV respectively were conducted. The values of voltage were chosen due to capacitors limitations. Input energy values to discharge were about 3 J to 15 nF and 200 J for 2 mkF. The flow rate of air was 110 cm³/s. During the experiment digital camera with frequency 30 frames per second was used. That allows us to estimate the time interval between frames – 30 ms. Oscillograms of voltage and current of discharge and corresponding video fames of discharge process are shown on Fig. 5 and 6. Missed shots mark flashes too bright for the camera.

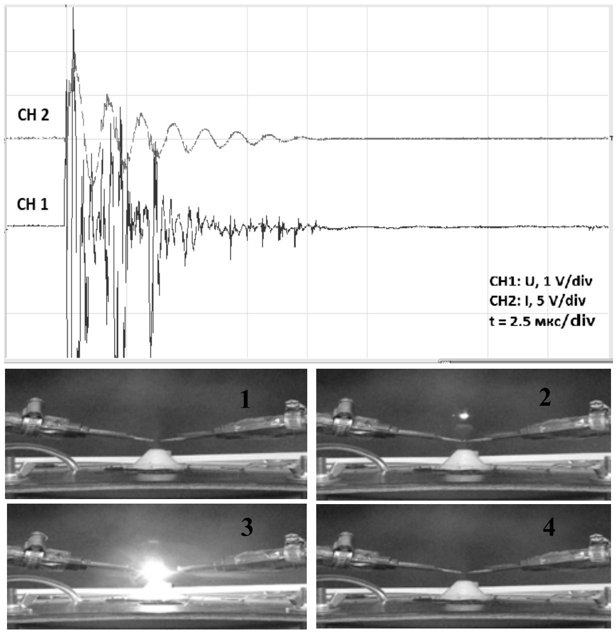

Fig. 5. Oscillograms of voltage and current and the video frames of discharge process: C = 15 nF, U = 19.5 kV, I = 940 A, aerosol (G = 110 cm³/s)

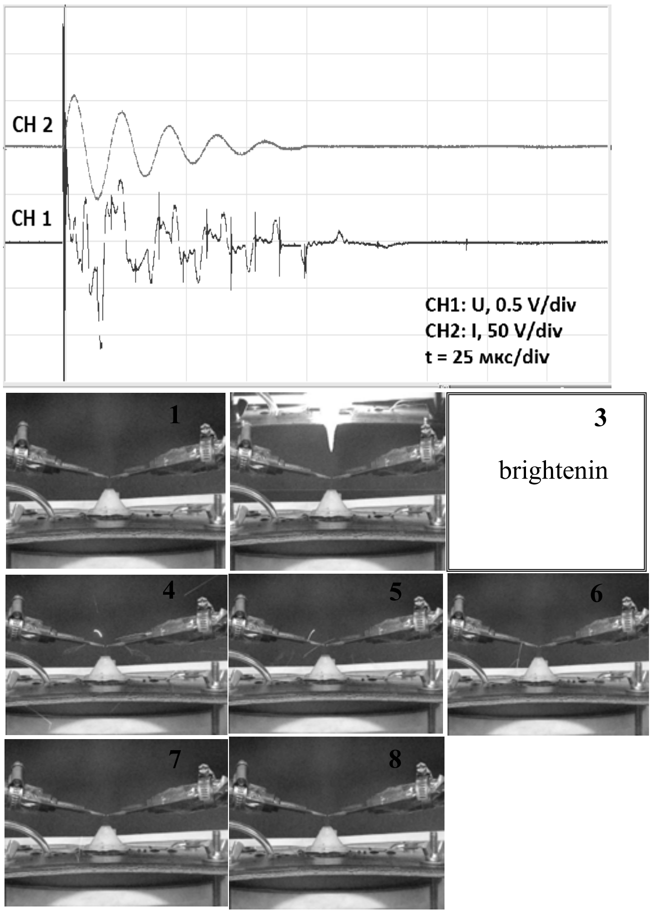

Fig. 6. Oscillograms of voltage and current and the video frames of discharge process: C = 2 mkF, U = 14 kV, I = 7.5 кА, aerosol (G = 110 cm³/s)

Measured time damping oscillations of voltage and current were 10 mks for capacitor 15 nF and 100 mks for 2 mkF capacitor. The discharge with capacity of 2 mkF differs from the discharge with 15 nF. It was noted the presence of an explosive process after flash of discharge. This process can be explained by the formation of mixture of H_2 and O_2, which interacts causing an explosion. In the discharge of this capacity was present destruction of tip of electrodes.

In the frame preceding the outbreak in Fig. 5 can be clearly seen shining formation, localized near the electrodes. This formation can be a flash of illumination in air switch or leading plasma formation prior to breakdown.

On Fig. 6 on the frame to go after the outbreak was observed traces formed by the movement of particles that glow. Two plausible mechanisms of their formation were considered. According to the first this formation is metal particles that scatter after discharge, but this theory questioned the lack of glow of tip of electrodes. In another mechanism of formation this is stable plasma formations with accumulated energy in them.

CONCLUSIONS

The duration of glowing in discharge area was in a few times longer then the duration of discharge current impulse.

Research are showed that the impulse electric discharge in aerosol with energy close to 200 J leads to volumetric process with changed spectrum and generation of plasmoids which have lifetimes of >100 ms without support of discharge.

ACKNOWLEDGEMENTS

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REFERENCES

1. A.I. Egorov, S.I. Stepanov, G.D. Shabanov. Demonstration of ball lightning in the lab // *Physical Sciences Success.* 2004, v. 174, № 1, p. 107-109 (in Russian).
2. B. Juettner, S. Noack, A. Versteegh, G. Fussmann. Long-living Plasmoids from a Water Discharge at Atmospheric Pressure // *28th ICPIG, Prague, Czech Republic 15-20 July.* 2007, p. 2229-2232.

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ПОЛУЧЕНИЕ И ИССЛЕДОВАНИЕ СВОЙСТВ ПЛАЗМЕННЫХ ОБРАЗОВАНИЙ ПРИ ИМПУЛЬСНОМ РАЗРЯДЕ В ВОДНОМ АЭРОЗОЛЕ

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Представлены результаты исследования электрофизических и спектральных свойств плазмы импульсного разряда в аэрозоле. Были измерены ток разряда, напряжение и интегральный спектр плазмы. Область разряда наблюдалась с помощью цифровой камеры. Наблюдалось появление плазмоидов с временем жизни порядка 150 мс в автономном режиме (после прекращения тока разряда).

ОТРИМАННЯ ТА ДОСЛІДЖЕННЯ ВЛАСТИВОСТЕЙ ПЛАЗМОВИХ УТВОРЕНЬ ПРИ ІМПУЛЬСНОМУ РОЗРЯДІ У ВОДЯНОМУ АЕРОЗОЛІ

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Представлені результати дослідження електрофізичних та спектральних властивостей плазми імпульсного розряду в аерозолі. Були виміряні струм розряду, напруга та інтегральний спектр плазми. Область розряду спостерігалась з допомогою цифрової камери. Спостерігалась поява плазмоїдів з часом життя близько 150 мс в автономному режимі (після припинення струму розряду).