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STUDY OF BARRIER PULSE-PERIODIC ATMOSPHERIC PRESSURE GAS DISCHARGE AT HIGH PULSE REPETITION FREQUENCIES*

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Homogeneous (diffuse) glow discharges occurring at atmospheric working gas pressure are attractive sources of nonequilibrium nonstationary plasma with a wide range of applications. Currently, electrophysical devices for generating high-voltage pulses with nanosecond and subnanosecond fronts allow to ignite the gas discharge at high pressures and provide volumetric character of current flow in the time range, less than the time of spark processes development. Appearance of commutation semiconductor and gas-discharge devices of nano- and subnanosecond range functioning at high pulse repetition frequencies gave an opportunity to investigate original properties of atmospheric pressure discharge at pulse repetition frequencies of tens to hundreds kHz. This is interesting from the point of view of introduction of significant pulse and medium pumping powers into the working media.

The aim of this work was to study the conditions of volumetric current flow in atmospheric pressure gases using the physical and technical capabilities of switching devices - eptrons for generating high-voltage (up to ~ 40 kV) short (~ 10-30 ns) pulses with nanosecond fronts and capable of functioning at high pulse repetition frequencies (up to f ≈ 100 kHz).

The studies were carried out in a cell designed to implement and study a simple high-voltage gas discharge between flat electrodes: a titanium anode and a dielectric cathode with a diameter of 19 mm (cathode–anode distance 7 mm) in the mode of a train of pulses with a train frequency of 10 Hz with a filling frequency of regular pulses f = 5–100 kHz and voltage amplitude U = 2–35 kV with adjustable pulse front duration τ = 1.5–10 ns in helium at atmospheric pressure. A feature of the cathode was that it consisted of a set of Al_2O_3 plates with a thickness of ~0.6 mm, which made it possible to change the cathode thickness h in the range h = 2–7 mm.

Dependences of current amplitude on voltage amplitude I(U) at different pulse repetition frequencies f= 25, 50 and 100 kHz with cathode thickness h = 7 and 2 mm were studied. At U > 10 kV in the cuvette a spatially homogeneous - diffuse discharge occurs and up to U ≈ 30 kV a volumetric current flow was observed. The combination of results demonstrated that I(U) do not depend on pulse repetition frequency; in the cuvette with thinner cathode, other things being equal, ~3 times higher currents are achievable, but with decrease of operation limiting frequencies (the discharge moves faster from volumetric to filament stage); reduction of the excitation pulse front duration τ does not affect the value of achievable current, but allows increasing the limit operating voltage with preservation of the volumetric character of current flow, while decreasing the pulse repetition frequency does not change the picture. Experiments have shown that the time delay of the maximum current from the beginning of voltage at different voltage front durations at different frequencies decreases with increasing U and for smaller τ more rapid development of the discharge and larger achievable voltages are characteristic. The results of the experiments demonstrated that decreasing the pulse repetition frequency is accompanied by improving the stability of the discharge. Numerical simulation of gas discharge ignition in helium at p_{He} = 1 atm was performed within the framework of the hydrodynamic approach in a two-dimensional setting with cylindrical symmetry

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