ATMOSPHERIC PRESSURE GAS DISCHARGE EXCITED BY NANOSECOND PULSES AT 100 KHZ [1]

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Studies of atmospheric pressure gas discharges were carried out in order to create gas-discharge high-energy devices (reactors) for dissociation of complex gaseous chemical compounds and neutralization of environmentally harmful volatile compounds. The idea was to use the physical and technical capabilities of new developed switching devices (eptrons) to generate high-voltage (up to 50 kV) short pulses (10–30 ns) with nanosecond edge (1-2 ns), capable to function at high pulse repetition frequencies (up to $f \sim$ 100 kHz) to study the conditions of volume current flow in gases up to atmospheric pressure.

Two types of the cells were used in the experiments. In the first one a 5 mm discharge gap was formed by a cathode made of $BaTiO_3$ or SiC ceramics and a metal anode in the form of a ball with diameter of 26 mm. Another one had a planar design with two discharge gaps separated by a drift space, in which one-directional or counter-propagating electron beams could be formed. A gas-discharge switch (eptron) with an additional pulsed pre-ionizing discharge between cathodes and additional grid electrodes was used for rapid voltage rise. Power supply provided pulses up to 40 kV with leading edge up to 1 ns on the active load. The experiments were carried out in the burst operation mode with a burst repetition frequency of 5 Hz and a pulse repetition frequency in the burst of 1-100 kHz.

In the first cell pure helium at p_{He} = 1 atm was used as operating gas. At excitation parameters U= 20–25 kV and f = 1–20 kHz the discharge had an non-homogeneous form and represented a stable set of separate plasma channels. Increasing the frequency f and the number of pulses in the burst up to 200 led to the fact that from f > 50 kHz up to the maximum f = 100 kHz the discharge was spatially uniform. Decreasing of the discharge capacity led to the uniform mode of the current flow in the whole investigated range of pulse repetition frequencies $f \approx$ 10-100 kHz. Fig.1 shows photos of the discharge glow for the helium pressure p_{He} in the range of 20-1000 mbar. Typical oscillograms of U and I pulses are shown in Fig. 2. It can be seen that for U = 20 kV the voltage pulse edge is ~ 2 ns, current $I \sim$ 250 A (rise rate 25A/ns), and I increases with increasing gas pressure.

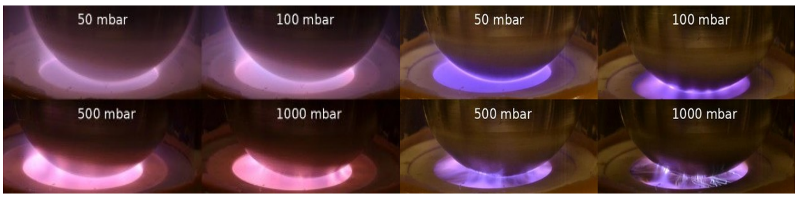

Fig.1 Photographs of discharge glow at different pressures of helium (a), nitrogen (b).

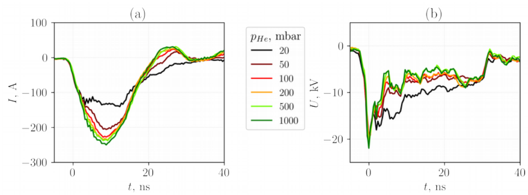

Fig.2 Oscillograms of current (a) and voltage (b) at different nitrogen pressures

Similar experiments with nitrogen as operating gas demonstrated the homogeneous form of the discharge up to 100 mbar with the following stochastic nature of the gas discharge, with I weakly depending on the gas pressure. The oscillograms of U and I during electrode short-circuiting and in the case of discharge show that the short-circuiting current is more than 2 times higher than the discharge current, which indicates the absence of the discharge spark phase.

The experiments in the second cell demonstrated that spatially homogeneous discharge in air is stable up to p ≈ 0.5 atm for the case when one acceleration gap is used (one-directional electron beam). In case of applying 2 acceleration gaps (counter-propagating electron beams), the discharge is stable up to p = 1 atm. At f = 90 kHz, stable discharge burning was achieved with average power during the burst of 3.5 kW, which corresponds to input power per unit volume ~18 kW/cm^3.

[1] The work was supported by the Russian Science Foundation (project No. 19-19-00069).