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PULSED DISCHARGE OF ATMOSPHERIC PRESSURE IN AIR AND IN METHANE WITH PULSE DURATION OF 1 ns

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Today major researches in plasma chemistry are carried out with application of gas discharge plasma. Usually DC corona discharges are used and AC barrier discharges. In recent years interest to short gas discharge with excitation pulse duration from microsecond to nanosecond [1] has grown anew. Application of such discharge allows of improvement of plasma stability, increasing specific power input into gas, and generation of volumetric diffuse excitation of the medium. In this report we represent characteristics of similar discharge with excitation pulse duration approximately 1 ns; that is intended for examination of plasma catalytic conversion of methane.

Design of discharge cell is similar to that described in [2]; Figure 1 shows the cell diagram. Discharge is performed between cathode C and planar anode A. The cathode represents a set of copper pins with diameter of 0.3 mm (1, 2 or 4 pieces), fixed at the end of high-voltage cable. The cathode and anode were placed into quartz tube. Tubes of inner diameter 20 and 26 mm were used; the anode diameter corresponded to that of the tube. Cell was filled with gas (air or methane), gas pressure could vary from 0.2 to 1.5 bar. In a number of experiments the discharge was performed through a layer of zeolitic grains (of diameter 0.3 mm) located at the anode. Layer thickness was varied from 1 mm to 6 mm. In those experiments conditions for activation of methane conversion catalyst were simulated.

For discharge excitation high-voltage pulse generator Proto-1m [3] was used. The generator characteristics are the following: voltage pulse duration (FWHM) is 1 ns, high-voltage pulse peak value is 50 kV, and pulse repetition rate is up to 100 Hz.

Discharge cell was connected to high-voltage generator with 50-Ohm cable of 1-meter length. Discharge current pulse from shunt R and voltage pulse from generator divider were recorded by TDS-5054 oscilloscope.

Major experiments were carried out with discharge in the air; discharge current was measured at different anode-cathode distances d and gas pressure. Standard distance between anode and cathode comprised approximately 10 mm, at the same time the discharge was diffuse, discharge current pulse peak value was 700 A (for 4-pin cathode), pulse duration at half-height was 0.8 ns. From each cathode's pin discharge column of 4 mm diameter at basis on anode was formed. We estimate the excited gas volume as approximately 0.4 cm^3 for d=10 mm.

As the cathode-anode distance is reduced discharge current increases and at d=4 mm and current peak equal to 1000 A discharge transforms from diffuse discharge into spark discharge. When d is increased the current decreases and at d=15 mm the discharge transforms into pulse corona discharge with current below 100 A. As the air pressure is decreased the discharge current peak increases from 400 A at 1.5 bar pressure to 900 A at 0.2 bar pressure.

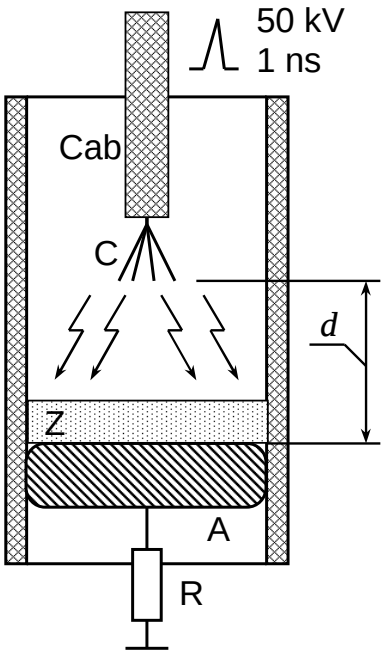

Fig. 1: Discharge cell diagram. C – cathode, A – anode, Cab – HV cable, Z – zeolite, R – shunt, *d* – discharge gap distance

Zeolitic layer modeling the methane conversion catalyst decreases the discharge current but the discharge remains diffuse if the layer thickness is less than 5 mm (with d=10 mm). For 5 mm layer the discharge current decreases by 30% from initial current. If the zeolitic layer thickness exceeds 5 mm the discharge transforms into spark discharge.

In methane the discharge is also diffuse and the discharge current is approximately by 10% higher than the discharge current in the air in similar condition and current pulse duration comprises approximately 1 ns.

Thus, application of short excitation pulse with duration of 1 ns allows of generation of diffuse high-voltage discharge of atmospheric pressure in air and methane. We have demonstrated the possibility to place catalyst into the discharge area without significant deterioration of discharge parameters. Specific power introduced into the gas comprises approximately 80 mJ/cm^3 per 1 pulse at plasma volume of 0.4 cm^3 and discharge current pulse duration of 0.8 ns.

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Reference

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