Compact generator of 240 kV atmospheric pressure nanosecond discharge

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Herein compact device for generation of pulsed atmospheric pressure discharge is described. As a discharge power source, we use generator of high-voltage pulses with output voltage of 240 kV, current pulse' amplitude of up to 3.5 kA and output pulse' length of 15 ns. Under change of discharge conditions at the device, it is possible to get pulsed corona, diffuse, glow or spark discharges.

High-voltage pulse discharges are widely used in different areas of plasma physics and plasma chemistry [1]. Interest in such discharges is connected with possibility of considerable increase of energy deposition into gas in comparison with DC discharges. Besides, application of short pulsed discharges ensures volumetric character of excitation even under high pressure of gas.

We have used gas discharge, described in [2], for plasma chemical conversion of methane. This discharge has pulse length of 1 ns and voltage of 50 kV, it is convenient for execution of researches, it works stably under atmospheric pressure, but volume of generated plasma is relatively low and does not exceed 10 milliliters. For increase of volume of gas mixture treatment, we have developed a device with discharge voltage of up to 240 kV.

As discharge power supply, we have used generator of high-voltage pulses SM-4N. Distinctive feature of mentioned generator is completely solid-state switching system for high-voltage circuits of inductive storage, based on semiconductor opening switches (SOS-diodes)[3,4]. Application of solid-state breakers secures considerable operational lifetime, high stability of output pulses, small size of the device. Main characteristics of the generator: voltage pulses' amplitude – up to 240 kV, voltage pulses' polarity - negative, current pulses' amplitude – up to 3500 A, current pulse' length (FWHM) – 15 ns, maximum pulse repetition rate – 100 Hz, overall dimensions – 21x23x75 cm^3. Figure 1,a depicts appearance of the generator; figure 1,b shows dependence of amplitude values of voltage and current pulses on load resistance.

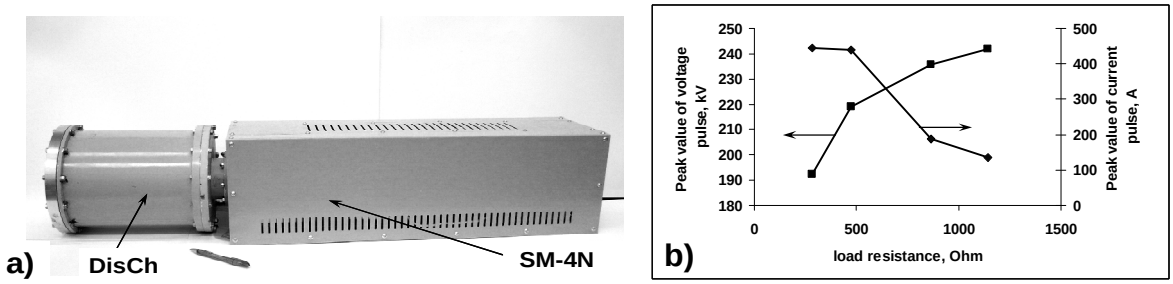

Fig. 1: a) - appearance of the generator SM-4N and discharge chamber (DisCh); b) - dependence of peak values of voltage and current pulses on load resistance

For generation of gas discharge, we have connected to HV generator a cylindrical discharge chamber with diameter of 20 cm and length of 25 or 50 cm (Fig.1,a). Depending on shape and layout of electrodes in chamber, different types of discharge are generated in the chamber: corona, diffuse, spark or glow discharge. Discharge current has been measured with the use of shunt, which connects body of discharge chamber and generator. Under examination of discharge, discharge current pulse and high-voltage pulse from generator divider have been registered by oscilloscope.

Pulsing corona discharge is generated under application of coaxial scheme and central electrode with diameter of 1 mm. Figure 2,a depicts dependence of corona discharge current on pressure for argon, air and mixture CH_4/CO_2. Under pressure of less than 0.1 bar for given configuration of electrodes, glow discharge takes place.

Volumetric diffuse and spark discharges have been generated between pointed cathode and planar anode. Under execution of experiments, we have measured discharge current under different distance *d* between cathode and anode. With decrease of *d*, the diffuse discharge transforms to spark. Figure 2,b shows dependence of discharge current on distance between anode and cathode for air under pressure of 1 bar. If d is greater than 30 mm, discharge remains diffuse, under d, which is less than 30 mm, spark discharge is generated. Under d, which is greater than 50 mm, discharge current dramatically decreases to 200 A and corona discharge is generated.

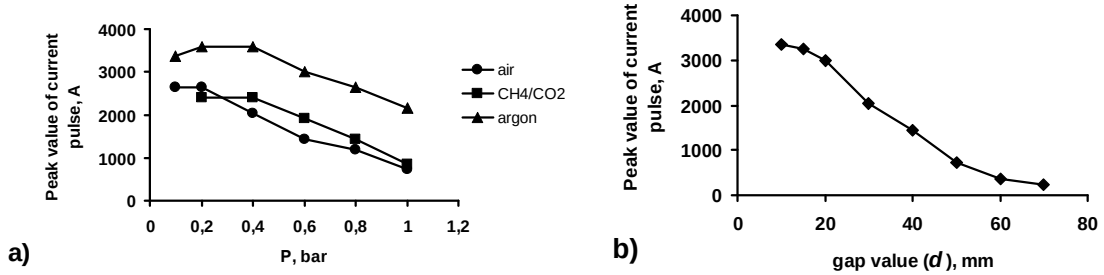

Fig. 2: a) - dependence of peak values of corona discharge current on pressure for air, argon and mixture CH_4/CO_2 (1:1); b) - dependence of peak values of current pulses on gap value for air under pressure of 1 bar

In addition, replacement of gas discharge chamber by tube diode with explosive-emission cathode makes it possible (by analogy with [5]) to generate electron beam with electron energy of 200 keV, current pulse amplitude of 100 A and pulse width of 10 ns.

Thus presented device is a compact desktop device for generation of different types of atmospheric pressure gas discharges, including pulsed corona, diffuse, glow and spark discharges. Present device is used currently for studies in plasma chemistry of methane.

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References

[1] J. Pouvesle, 2009 *ISPC19 – Proceedings* PL5
http://www.ispc-conference.org/ispcproc/papers/807.pdf
[2] V. Uvarin, D. Kuznetsov, S. Lyubutin, B. Slovikovskii, ESCAMPIG XX-2010, Proceedings, P3.45. http://escampig2010.ipb.ac.rs/papers/P3.45.pdf
[3] http://eng.iep.uran.ru/razzr/gener/razr_2.html
[4] S.N. Rukin, Instruments and Experimental Techniques **42**(4), 439 (1999)
[5] V. Uvarin, D. Kuznetsov, S. Lyubutin, B. Slovikovskii, 2009 *ISPC19 – Proceedings* P1.5.39
http://www.ispc-conference.org/ispcproc/papers/700.pdf