S4-P-017502

NANOSECOND SWITCHES BASED ON THE CAPILLARY DISCHARGE WITH HOLLOW CATHODE*

P.A. BOKHAN, P.P. GUGIN, M.A. LAVRUKHIN, D.E. ZAKREVSKY

A. V. Rzhanov Institute of Semiconductor Physics SB RAS, Novosibirsk, Russia

Capillary discharge applications include a wide range of areas, such as UV and X-ray sources, generation of high-voltage nanosecond pulses, etc. In a number of recent papers [1, 2] the unique ability of nanosecond switches based on capillary discharge to operate at high pulse repetition frequency (PRF) has been demonstrated. In burst operation mode, with optimization of external conductive shield around the capillary, PRF more than 100 kHz was achieved [3]. Such values make these switches promising for a number of applications, such as plasma processing, excitation of gas lasers, etc.

Nevertheless, the development of models of the considered type of the switch, capable to operate in the regular pulses mode at high PRF values (50-200 kHz and more) and high average switching power ~1-10 kW, is associated with a number of difficulties, caused by intensive heat dissipation inside the switch. In particular, it leads to a change in gas composition and pressure in the switch volume, which negatively affects the switching characteristics and lifetime of the device. One of the ways to mitigate this problem is the maximum simplification of structural parts of the switch, particularly the cathode node and capillary structure, with minimal deterioration of the switch operating parameters.

In most recent works devoted to the study of switching characteristics of the capillary discharge, a rather complicated discharge structure has been used as a plasma cathode. Particularly, it is due to the preionization of the cathode region in order to increase the switch efficiency. Nonetheless, it has been demonstrated in [4] that additional ionization does not play a significant role at PRF greater than 20 kHz. Regarding the capillary configuration, in [3] it was suggested that the process of formation of runaway electrons in the capillary region has a significant influence, which leads to a decrease in the degree of pulse compression and the maximum achievable PRF values. However, direct experiments demonstrating the influence of the capillary structure shape haven't been presented.

Comparative experimental studies of several switches with different capillary configurations were performed in this work. In all cases, a hollow cylindrical Ti cathode with an inner diameter of 2.6 cm and a length of 90 cm was used as a cathode node. In the side surface of the cylinder a rectangular hole was formed to which a capillary of rectangular cross section made of Al_2O_3 plates was attached. Studies were carried out using helium with pressure of 2-20 mbar as a working gas of the switch. To form high-voltage pulses on the operating capacitance primary generator with a PRF of up to 200 kHz in the burst operation mode was used.

REFERENCES

[1] P.A. Bokhan, P.P. Gugin, M.A. Lavrukhin, I.V. Schweigert, A.L. Alexandrov, D.E. Zakrevsky, “A high-voltage subnanosecond sharpener based on a combination of 'open' and capillary discharges”, J. Phys. D: Appl. Phys., vol. *51*, p. 364001, 2018.

[2] P.A. Bokhan, P.P. Gugin, D.E. Zakrevsky, M.A. Lavrukhin, “Frequency Characteristics of a Subnanosecond Plasma Switch”, Russian Physics Journal, Vol. 62, № 11, p. 2059, 2020.

[3] P.A. Bokhan, E.V. Belskaya, P.P. Gugin, M.A. Lavrukhin, D.E. Zakrevsky, I.V. Schweigert, “Investigation of the characteristics and mechanism of subnanosecond switching of a new type of plasmas switches. II switching devices based on a combination of ‘open’ and capillary discharges —eptrons”, Plasma Sources Science and Technology, vol. 29, p. 84001.

[4] P.A. Bokhan, M.A. Lavrukhin, D.E. Zakrevsky, “Influence of the cathode region preionization on the operating parameters of the eptron” Journal of Physics: Conference Series, vol. 2064, p. 12125, 2021.

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