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OPERATION FEATURES AND EMISSION CHARACTERISTICS OF A CONSTRICTED ARC DISCHARGE FORMING EMISSION PLASMA IN A FOREVACUUM PLASMA-CATHODE SOURCE OF A PULSED ELECTRON BEAM*

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A cathodic arc (an arc discharge with cathode spots) is rather often used to generate emission plasma in pulsed plasma-cathode electron beam sources [1, 2]. The cathodic arc provides high current and long pulse duration of the discharge current and accordingly of the electron beam current. On the other hand, the cathodic arc has some disadvantages caused by the chaotic movement and instabilities of cathode spots, and by formation of vapors and microdroplets of the cathode material during cathode spot operation. These disadvantages affect the characteristics and operation parameters of the plasma-cathode electron sources (e.g., it leads to decrease of electric strength of an accelerating gap). A constricted arc discharge is used to eliminate the disadvantages of the cathodic arc in the sources generating electron beams in the conventional gas pressure range of 10^{-4}–10^{-1} Pa [1, 2]. The forevacuum plasma-cathode electron sources, generating electron beams at higher pressures, operate in the isobaric mode, i.e., the pressures in the vacuum chamber and in the source are the same. Therefore, there is practically no pressure difference between the cathode and anode regions of the constricted arc discharge. This leads to specific features of the formation of the emission plasma by the constricted arc discharge in the forevacuum plasma-cathode electron source [3].

The aim of this work was to research operation features and emission characteristics of a constricted arc discharge forming emission plasma in a forevacuum plasma-cathode source that generates a pulsed electron beam at pressure of 3–20 Pa. In case of helium as working gas, the use of a metallic intermediate electrode with a constricting channel has not ensured stable operation of the constricted arc discharge with current more than 4 A and pulse duration longer than 15–20 μs due to the transition to the cascade operation mode. The cascade mode is discharge operation with cathode spots on the intermediate electrode, i.e., discharge consists of two serial cathodic arcs. The use of the intermediate electrode made of high-temperature ceramic has provided a rather stable current flow through the constricting channel. However, short spikes in the burning voltage of the constricted arc during a pulse have been observed. The amplitude of these spikes could reach several hundred volts. Voltage spikes in the discharge voltage are due to voltage fluctuations on the electric double layer near the constricting channel. Apparently, in case of the metallic intermediate electrode, these voltage spikes lead to an arc transition to the cascade operation mode. The ceramic intermediate electrode has also provided to increase a little maximum current and pulse duration of the constricted arc in case of using argon and nitrogen as working gases. Processes, occurring during the generation of the electron beam in the forevacuum pressure range, influence significantly on the constricted arc discharge. The maximum current and pulse duration of the constricted arc have increased in case of generation of the electron beam. An increase in these maximum parameters is provided by the back-streaming ion flow from the beam-produced plasma. Back-streaming ions penetrate into the discharge system of the plasma-cathode source through a mesh emission electrode and change the conditions for discharge operation. In particular, under the conditions of electron beam generation the probability of the transition of the constricted arc to the cascade operation mode has decreased. It was also found that length of an accelerating gap affects the maximum discharge parameters and the emission characteristics of the constricted arc. The efficiency of electron emission from arc plasma depends nonmonotonically on the length of the accelerating gap. The pulsed electron beam with energy up to 8 keV and current up to tens of amperes generated by the forevacuum plasma-cathode electron source based on the constricted arc has been obtained.

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