S5-O-018402

FEATURES OF RECORDING DISCHARGE CURRENT PULSES AT ELECTRON BEAM GENERATION IN A HIGH-VOLTAGE NANOSECOND DISCHARGE IN VACUUM AND GAS DIODES*

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From a practical point of view, the effect of cumulation (self-focusing) of an electron beam attracts, first of all, by the possibility of increasing the beam current density and, accordingly, increasing the power density in the cumulation zone. This can be used to generate highly ionized plasma and powerful X-rays, in the study of matter at elevated pressure and thermonuclear research [1], in the fields of radiation chemistry and solid state physics [2], to generate powerful radiation in the terahertz frequency range [3], luminescence excitation of artificial and synthetic crystals [4, 5] and in other applications. It was found that at currents of tens to hundreds of kA, the beam is focused by its own magnetic field [6]. At the same time, at currents not exceeding ~ 2 kA, beam focusing is treated differently. Thus, in the case of a vacuum diode with an annular graphite cathode, according to the developed model and experimental data, the relativistic electron beam is compressed due to the electrostatic repulsion of electrons emitted from the inner surface of the cathode [3]. The formation of a conductive plasma jet in a vacuum-pulsed discharge, consisting of several filaments with a diameter of ~ 50 μm and a current of ~ 1 kA in each of them, was reported in [7].

The purpose of this work was to study the effect of electron charge compensation on the self-focusing of an electron beam generated by a high-voltage nanosecond discharge in a nonuniform electric field in vacuum and gas diodes and to reveal the features of recording the discharge current under these conditions.

The results of the study indicate that, in addition to the effect of beam self-focusing, which realizes in the gas and vacuum diodes from the beginning of the beam current pulse, an additional self-focusing mechanism is activated in the gas diode several nanoseconds after the beginning of the pulse. The most probable reason for the additional self-focusing of the electron beam in a gas diode is the effect of compensation of the electron charge by the charge of positive ions arising as a result of gas ionization by beam electrons. The experimental data obtained and the result of the estimation of the characteristic time required to activate the charge compensation effect at a pressure of 0.2 Torr are close to each other.

It was found that the shape of the current pulse recorded by the current shunt under the conditions of electron beam generation during high-voltage nanosecond discharge in vacuum and gas diodes is determined by the influence of the reactive component of the voltage drop across the current shunt resistance.

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*This research was supported by the Ministry of Science and Higher Education of the Russian Federation within Agreement no. 075-15-2021-1026 of November 15, 2021.