MECHANISM OF ADDITIONAL SELF-FOCUSING OF AN ELECTRON BEAM GENERATED DURING A HIGH-VOLTAGE NANOSECOND DISCHARGE IN A GAS-FILLED DIODE*

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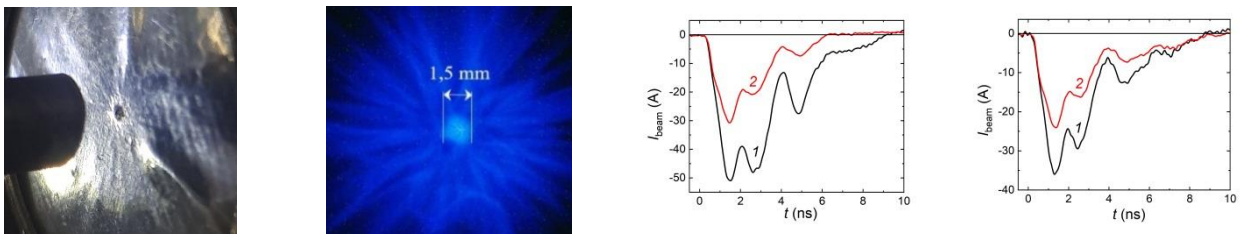
From a practical point of view, the effect of self-focusing (cumulation) of an electron beam [1, 2] is attractive, first of all, by the possibility of increasing the beam current density and, accordingly, increasing the power density in the cumulation zone. This effect can be used to generate highly ionized plasma and powerful X-ray radiation, in the study of matter at elevated pressure and thermonuclear research, in the fields of radiation chemistry and solid state physics, to generate powerful radiation in the terahertz frequency range, excitation of luminescence of artificial and synthetic crystals and in a number of other applications [3–5].

The effect of cumulation of an electron beam was studied during the formation of a high-voltage nanosecond discharge in gas-filled (air) and vacuum diodes (Figs. 1*ab*). It was established that in both cases the distribution of the beam current density in the plane of a grounded anode is non-uniform (Figs. 1*cd*). The highest beam current density occurs in the axial part of the anode. It was found that in the case of a gas diode (pressure 0.2 Torr), ~ 2 ns after the onset of the beam current pulse, the self-focusing effect is enhanced.



a) *b)* *c)* *d)*

Fig. 1. (*a*) Photo of a discharge gap with a hole formed in a 30-μm-thickness aluminum foil. (*b*) Glow of a plexiglass plate installed behind an anode made of a 15-μm-thickness aluminum foil. $p_{air} \approx 0.2$ Torr. (*c*, *d*) Waveforms of the current pulses of the electron beam passing through holes in the anode (one hole on the diode axis (curve *1*) and four holes on the periphery (curve *2*)) at pressures of 0.2 Torr (*c*) and 10^{-5} Torr (*d*).

The results of studies indicate that in a gas diode, in addition to the effect of self-focusing of the beam, a few nanoseconds after the onset of the beam current pulse, an additional self-focusing mechanism is activated. The most probable reason for the additional self-focusing of the electron beam in the gas-filled diode is the effect of compensation of the electron charge by the charge of positive ions arising as a result of gas ionization by electrons of the beam. The values of the characteristic ionization time τ_i required for the manifestation of the charge compensation effect at a pressure of 0.2 Torr obtained on the basis of experimental data and as a result of estimates are close to each other (~ 2 ns). Their real difference may be smaller if we take into account the possibility of forming at the initial stage a beam of electrons with an energy of less than 40 keV.

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* The work was performed in the framework of the State Task for IHCE SB RAS, # FWRM-2021-0014.