PRODUCTION OF INTENSE MICROSECOND RELATIVISTIC ELECTRON BEAMS

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An electron current up to 5 kA with pulse duration up to 4 μsec was obtained in a diode with a multiple-tip cold-emission cathode. The possibility of increasing the current-pulse duration are discussed.

Intense relativistic pulsed electron beams are obtained in accelerators in which storage lines are discharged into a diode [1] whose cathode emits electrons via explosive emission [2]. The maximum pulse duration of the electron current in such an accelerator is limited by the time during which the gap is short-circuited by the plasma produced by the explosion of the cathode tips and by the anode plasma produced when the anode is heated by the beam electrons [3]. The electron beams of modern accelerators therefore have lifetimes 10^{-8} - 10^{-7} sec. To eliminate the anode plasma it is necessary either to decrease the current density in the electron beam or to use a diode with a conical cathode and a conical anode in a longitudinal magnetic field, to prevent the electrons from striking the anode [4].

These measures, however, do not solve the problem completely, since we are left with the flare of the cathode plasma that is indispensible for the production of large electron currents.

We have produced relativistic electron beams in the kiloampere range, with durations of several microseconds. We used for this purpose a diode with a multiple-tip cathode of area 200 cm^2 and the interelectrode gap from 7 to 26 cm. These measures enable us to decrease the current density in the diode and to prevent the appearance of an anode plasma, and also to reduce greatly the influence of the cathode flare, since the plasma is made much more tenuous by having it spread over a large distance. The voltage scource in this accelerator was a Marx generator with voltage amplitude 0.4 - 1.5 MV.

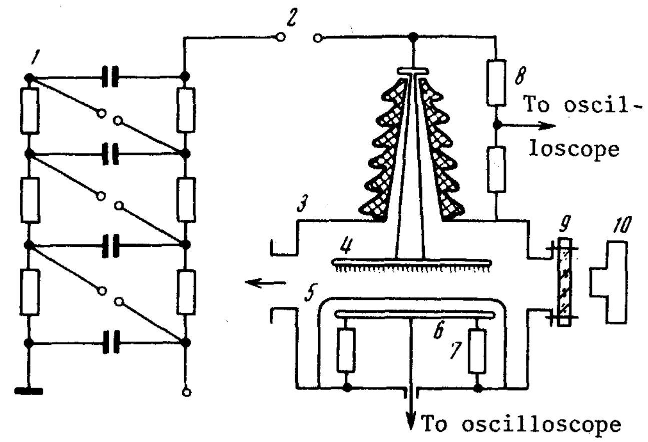

Fig. 1. Experimental setup: 1) voltage pulse generator, 2) discharge gap, 3) vacuum chamber, 4) cathode, 5) 70 μ aluminum foil extractor, 6) collector, 7) shunt for current measurement, 8) voltage divider, 9) window, 10) photographic camera.

The voltage was applied to a vacuum chamber in which the diode was placed (Fig. 1). A voltage divider and shunt were used to register the diode voltage and current oscillograms (Fig. 2), while the collector 7 registered the current of the electrons passing through an aluminum foil 70 μ thick. When the interelectrode gap was varied in the indicated limits, the electron current ranged from 5 to 2 kA with duration up to 4 μ sec. We photographed the picture of the glow in the interelectrode gap during the pulse duration, as well as the structure of the electron current to the anode. The latter was done with the aid of thin organic films.

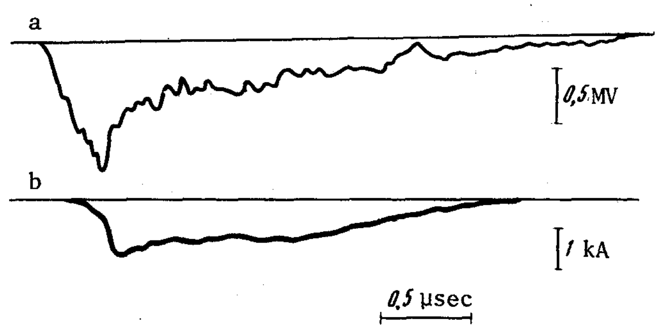

Fig. 2. Oscillograms of voltage (a) and current of diode collector at U = 1.2 mV and d = 17 cm.

The photographs of the accelerating

gap show very weak glow in the diode region; this glow is apparently due to evaporation of the adsorbed gas. They show also the bright glow of the plasma from the cathode flares at the tips. The intensity of this glow falls off rapidly in the radial direction. The region of visible glow penetrates not more than 5 mm into the interior of the gap (Fig. 2a). Our estimates show that at a voltage 10^6 V and at a current less than 100 A from one tip, the cathode plasma ceases to affect the switching in the accelerating gap if it reaches a dimension of 1 cm and more in the course of its expansion. The plasma concentration on the flare front becomes comparable with the concentration of the residual-gas particles. In this case, the duration of the current pulse is determined by the time of discharge of the pulse-generator capacitor into the diode resistance. It can be shown that this time is $\tau_{0.5} = 2.2\times10^5 Cd^2/S\sqrt{U_p}$, where $\tau_{0.5}$ is the current pulse duration at half height in seconds, C is the capacitance of the pulse generator in F, d is the interelectrode gap in cm, S is the cathode area in cm^2, and U_0 is the accelerating voltage in volts. The experimental results agree with this relation.

The structure of the beam (Fig. 2b) differs strongly from that obtained with this diode at 30 nsec pulse durations. Whereas in the former case it consists of individual rings obtained from each emitter, the microsecond pulses reveal irregularities that are probably due to the interaction between individual cathode flares.

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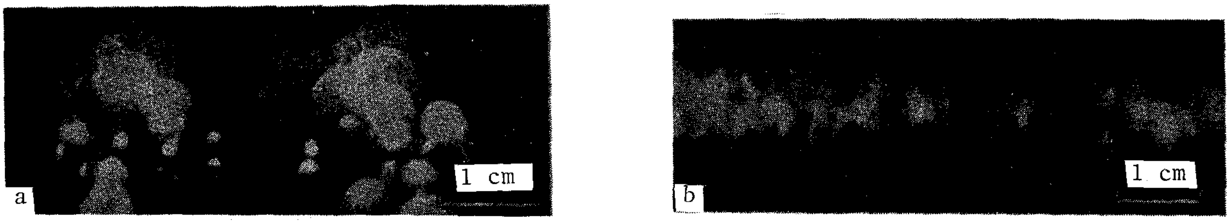

Fig. 3. Photograph of glow of near-cathode plasma: a) The cathode flares which are closer and farther from the focal plane seem to be diffused, owing to the small depth of focus of the lens. The focal plane is at the center of the photograph. b) Structure of electron current at the anode.

[1] S. E. Graybill and S. V. Nablo, IEEE Trans. Nucl. Sci., Vol. NS-14, No. 3, p. 782, 1967.
[2] G. A. Mesyats and D. I. Proskurovskii, ZhETF Pis. Red. 13, 7 (1971) [JETP Lett. 13, 4 (1971)].
[3] S. P. Bugaev, G. A. Mesyats, and D. I. Proskurovskii, Dokl. Akad. Nauk SSSR 186, 1067 (1969) [Sov. Phys.-Dokl. 14, 605 (1969)].
[4] M. Friedman and M. Ury, Rev. Sci. Instr. 43, 1659 (1972).

PHASE TRANSITIONS IN DILUTE FERRIMAGNETS AND THE PROBLEM OF LIQUID INFILTRATION

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In the simplest two-sublattice ferrimagnet, the spine of the atoms situated in two non-equivalent crystallographic positions are ordered antiparallel, and the spontaneous moment is due to an excess of atoms in one of the positions. There have been numerous investigations of dilute ferrimagnets in which some of the magnetic atoms in one sublattice was isomorphically replaced by nonmagnetic atoms. Whereas at low dilutions the behavior of such a ferrimagnet can be described well by the Neel theory, there is still no incontrovertible physical model for the region of large dilutions [1 - 4]. We have therefore performed a neutron-diffraction study of two systems of dilute ferrimagnets:

$$\text{I.}\ \{Y_{3-x}Ca_x\}[Fe_{2-x}Zr_x](Fe_3)O_{12} \qquad (0 \leqslant x \leqslant 2);$$

$$\text{II.}\ \{Y_{3-y}Ca_y\}[Fe_2](Fe_{3-y}Si_y)O_{12} \qquad (0 \leqslant y \leqslant 3)$$