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HIGH-INTENSITY PULSED ION BEAM GENERATION IN PLASMA EROSION MODE

A. PUSHKAREV, A. PRIMA, YU. EGOROVA

Tomsk Polytechnic University, 30, Lenin Ave, 634050 Tomsk, Russia, e-mail: aipush@mail.ru

The results of a study of the generation of high intensity pulsed ion beam in a diode with a passive anode when operating in a two-pulse mode are presented. When the polarity of the accelerating voltage changes, the plasma erosion mode [1] is realized in the A–K gap, ions are accelerated from the gas plasma, which can ensure the formation of a pulsed beam of gas ions, see Fig. 1.

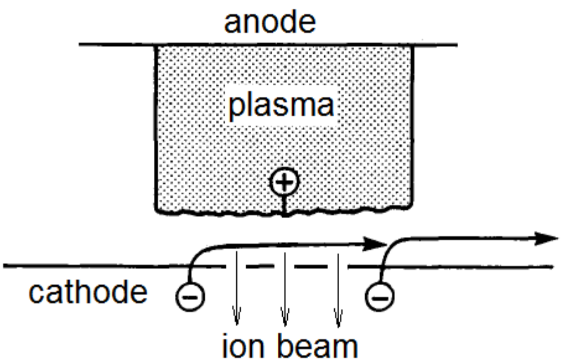

Fig. 1. HIPIB generation scheme in plasma erosion mode

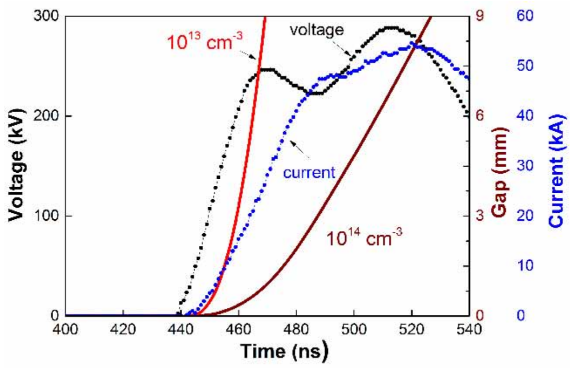

Fig. 2. Waveforms of accelerating voltage (second pulse), diode current and increasing of width of the vacuum gap λ near the cathode at different plasma density (line)

If the width of the vacuum sheath near the cathode in plasma erosion mode increases by an amount of $\Delta\lambda$ in a time of Δt, then the total ion and electron charge removed from the gap is:

$$\Delta Q = 2e \cdot n_0 \cdot S \cdot \Delta\lambda$$

where S - cathode area, n_0 - concentration of gas plasma.

Dividing both sides by Δt, we find the current in the diode:

$$I(t) = 2e \cdot n_0 \cdot S \cdot \frac{d\lambda}{dt}$$

Vacuum sheath near the cathode is:

$$\lambda(t) = \frac{1}{2e \cdot n_0 \cdot S} \int_{t0}^{\infty} I(t)dt$$

Fig. 2 shows the calculation of the vacuum sheath near cathode (λ) during the plasma erosion mode.

The analysis performed showed that in our experimental conditions [2], the concentration of gas plasma in the A-K gap does not exceed 10^{13} cm^{-3} and the pulse duration of the ion current generated in the plasma erosion mode will be less than 20 ns. However, the duration of the ions beam formed by an ion diode is ~200 ns [2]. In addition, the time-of-flight diagnostics of the ion beam shows a good agreement between the experimental and calculated pulse shape of the ion current density [2]. We simulated the signal profile from the collimated Faraday cup provided that the accelerating voltage is equal to the total voltage, applied to the diode. This corresponds to the condition of the acceleration of ions from a thin plasma layer on the surface of the anode, and not from the gas plasma in the A–K gap, see Fig. 1. Therefore, the generation of ions in a diode with a passive anode when operating in a plasma erosion mode is unlikely.

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[2] A.I. Pushkarev, Y.I. Isakova, A.I. Prima. Laser and Particle beams (2018), Vol. 36 (2), pp. 210-218.