EFRE 2020

CHARACTERISTICS OF A PLASMA ANODE BASED ON HYBRID DISCHARGE FOR THE USE IN A HIGH-CURRENT ELECTRON GUN

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Typically, low-energy (up to 30 keV), high current (up to 25 kA) electron beam formation is carried out in a high current gun with an explosive emission cathode and plasma anode based on a high-current reflective (Penning) discharge (RD). The operating experience with such guns showed that the electron beam formed in a double layer between the cathode and anode plasmas and being initially uniform in its cross section, transforms during transportation and acquires a pronounced maximum in the near-axis region. Beam uniformity can be improved, for example, by creating a plasma anode with increased plasma density at the periphery of plasma anode. For this purpose, we used a hybrid discharge combining a high-current RD with vacuum arcs initiated by a spark breakdown across dielectric surface.

SCHEMES OF ELECTRON GUN AND ANODE

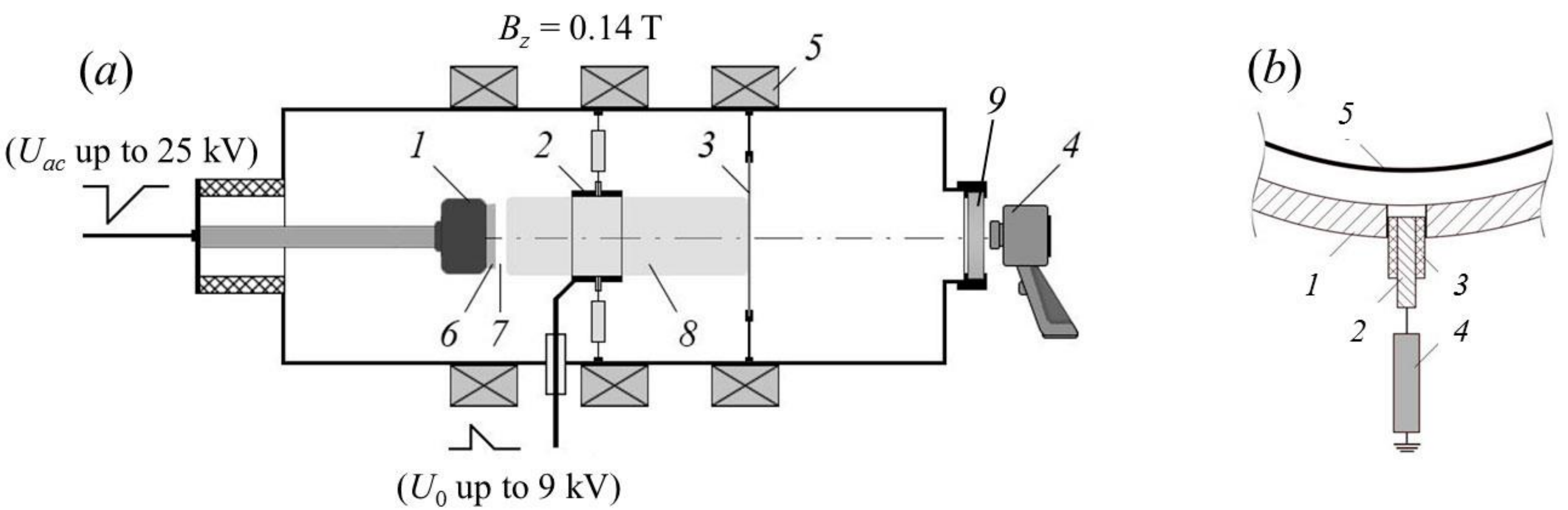


Fig. 1. ***a* – electron gun of the VEKSMA facility**: *1* – explosive-emission cathode, *2* – anode assembly, *3* – thermal imaging target (200-µm stainless steel foil), *4* – survey device digital camera CASIO QV-3000EX/Ir or thermal imager TESTO 875-1, *5* – solenoid, *6* – cathode plasma, *7* – double layer, *8* – anode plasma, *9* – infra-red window made of calcium fluorite; ***b* – anode assembly**: *1* – ring anode wall, *2* – copper cathode, *3* – ceramic tube, *4* – resistor TVO-2, *5* – screen.

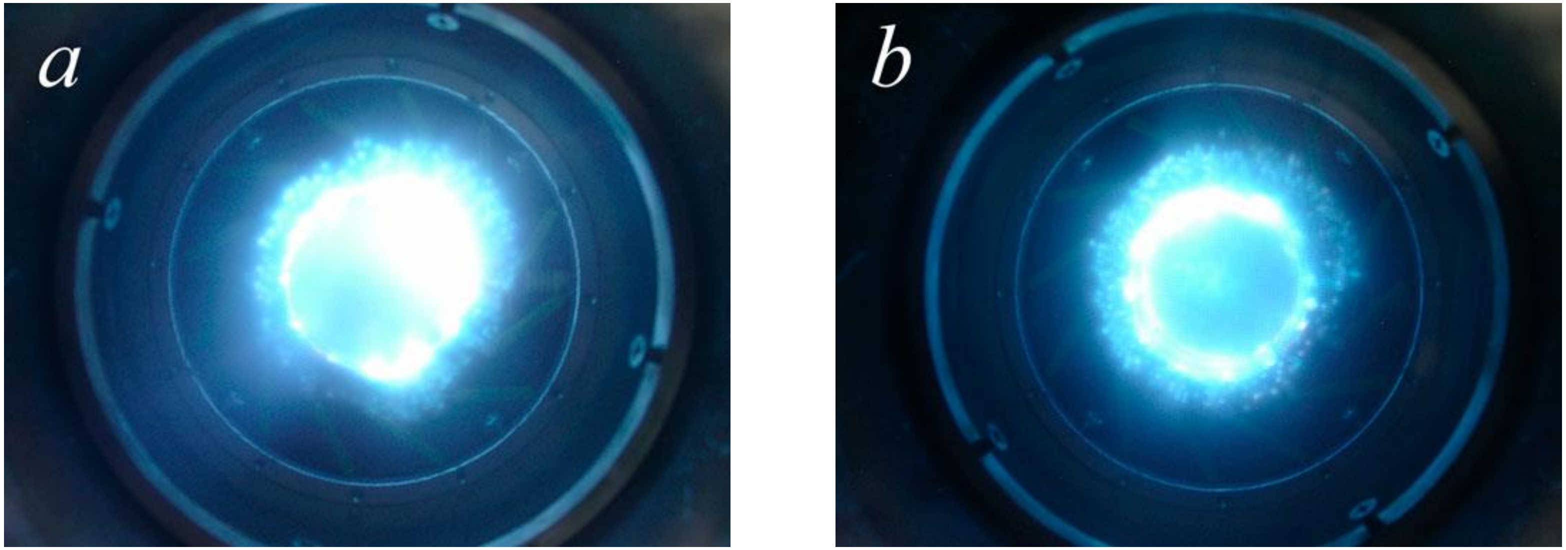
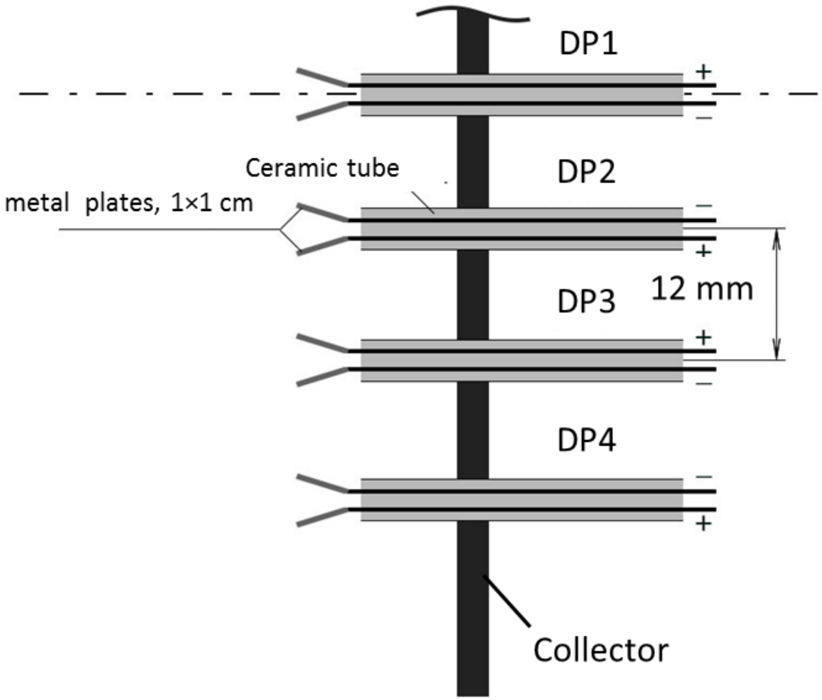


Fig. 2. Hybrid discharge glow: *a)* argon pressure – 0.5 mTorr, anode voltage – 8.4 kV, without the screen ; *b)* argon pressure – 0.6 mTorr, anode voltage – 8.4 kV, with the screen.



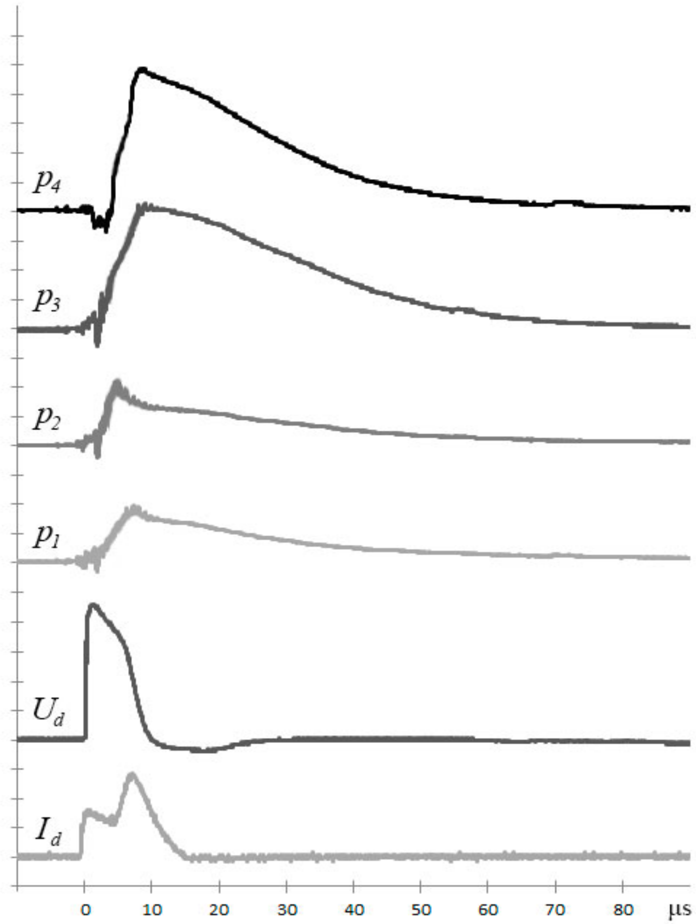


Fig. 3. Probe measurements scheme (left) and typical waveforms (right): probe currents (p_1–p_4, 0.1 A/div), discharge voltage (U_d, 1 kV/div) and discharge current (I_d, 400 A/div).

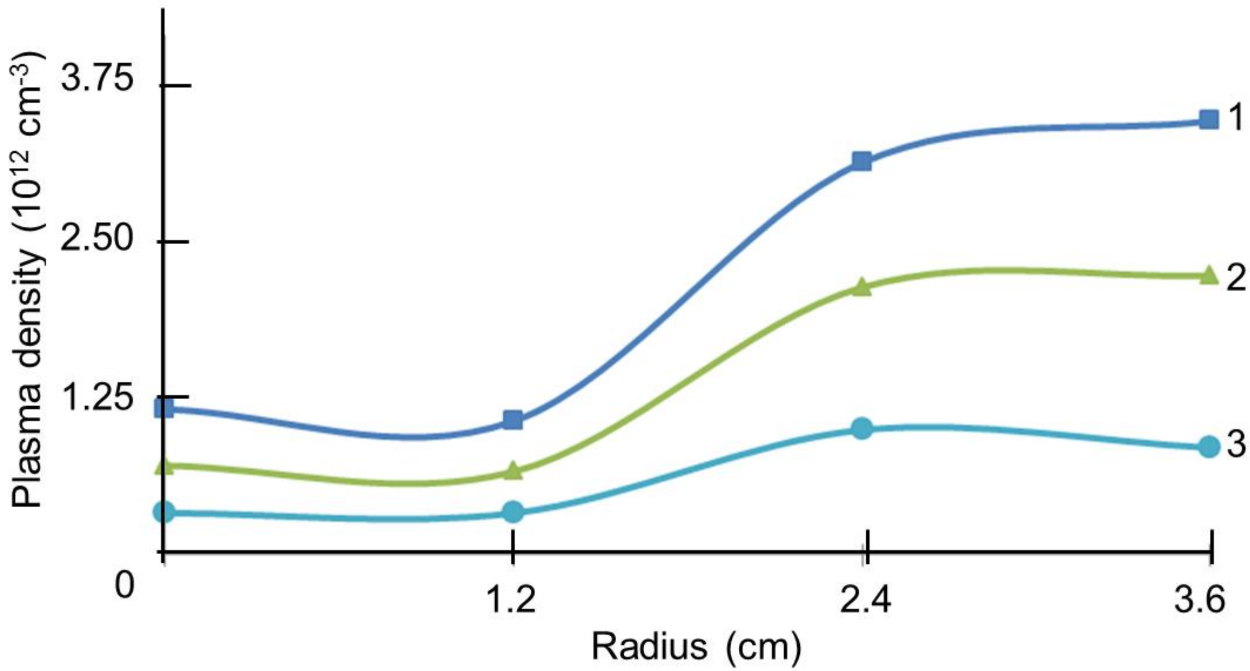


Fig. 4. Plasma density radial profile for the different time moments after the discharge start: 10 µs (curve 1); 30 µs (curve 2); 50 µs (curve 3). Argon pressure – 0.5 mTorr, guide magnetic field – 0.11 T, anode voltage amplitude – 6.7 kV.

THERMAL IMAGING MEASUREMENTS

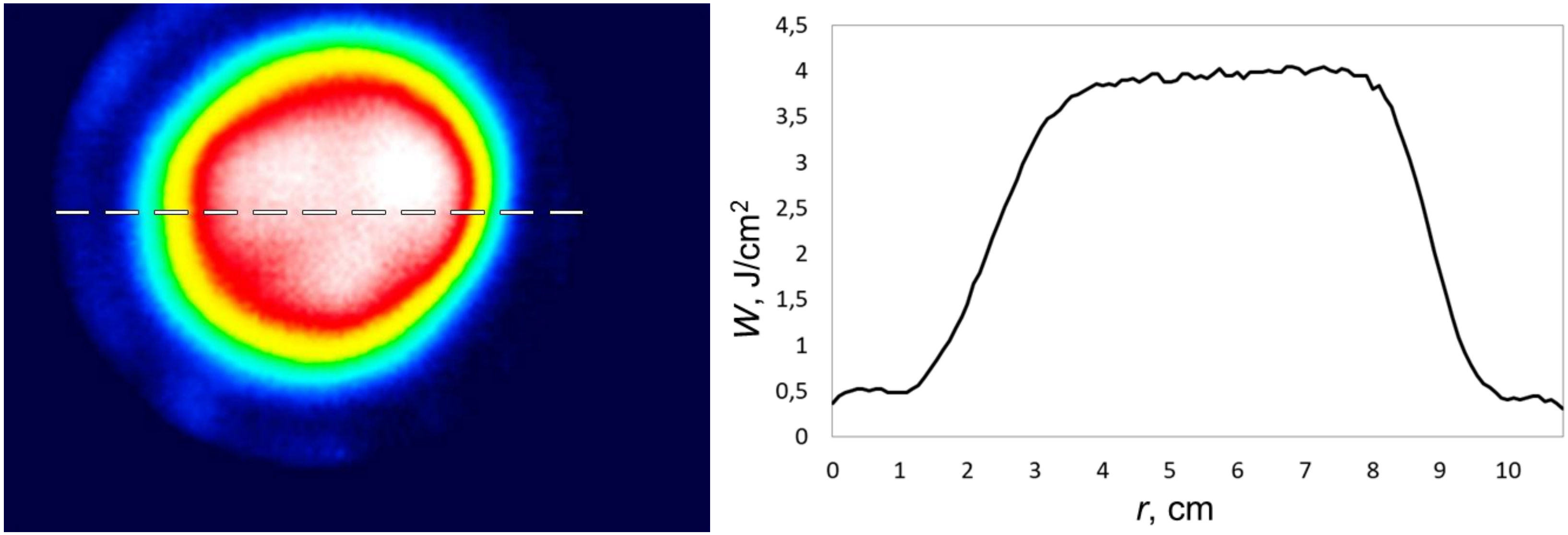


Fig. 5. Thermogram and corresponding energy density distribution via the beam cross section. Cathode with resistively decoupling of the emitters, hybrid anode with the screen of 15-mm height. Accelerating voltage amplitude is 20 kV, argon pressure is 0.4 mTorr.

CONCLUSIONS

1. The radial distributions of ions in the plasma anode formed with use of hybrid discharge combining high-current reflective discharge and vacuum arcs were measured by 4-channel double probe system. It has been shown, that ion density at the periphery of plasma anode exceeds its value in the central part by 2–3 times.

2. The obtained distributions allow one to select the modes of electron gun operation with improved uniformity of high-current electron beam.