EFRE 2020

Institute of High Current Electronics

Electron accelerator based on ion-electron emission for generation of a wide-aperture beam

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Outline

- *Relevance;*
- *Goals;*
- *Secondary ion-electron emission;*
- *Design and operation principle;*
- *Current voltage characteristics;*
- *Conclusion;*
- *Plans for the future.*

Relevance

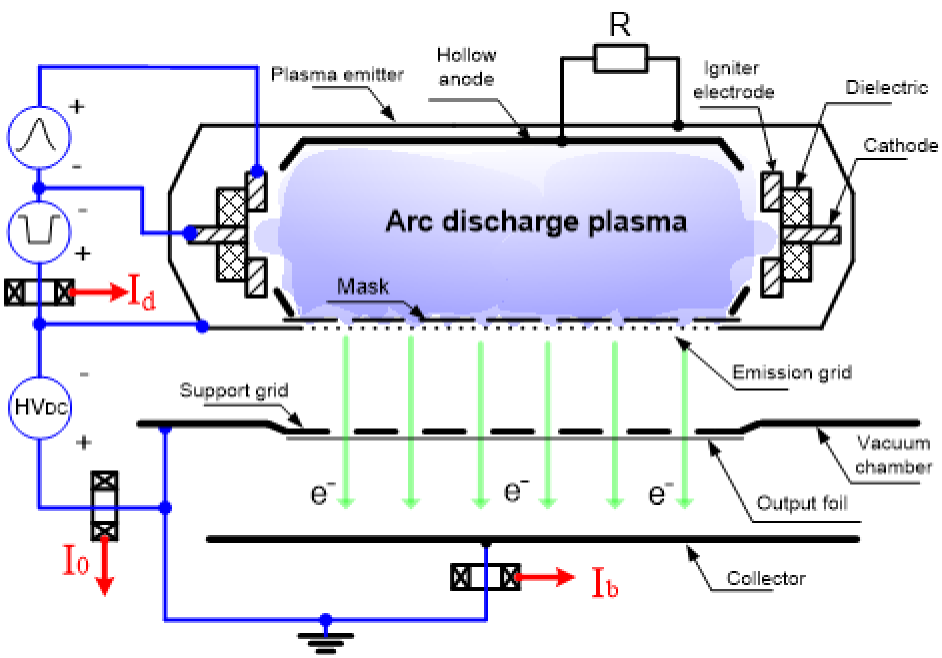


Fig. 1- The electron accelerator "Duet" with plasma cathode

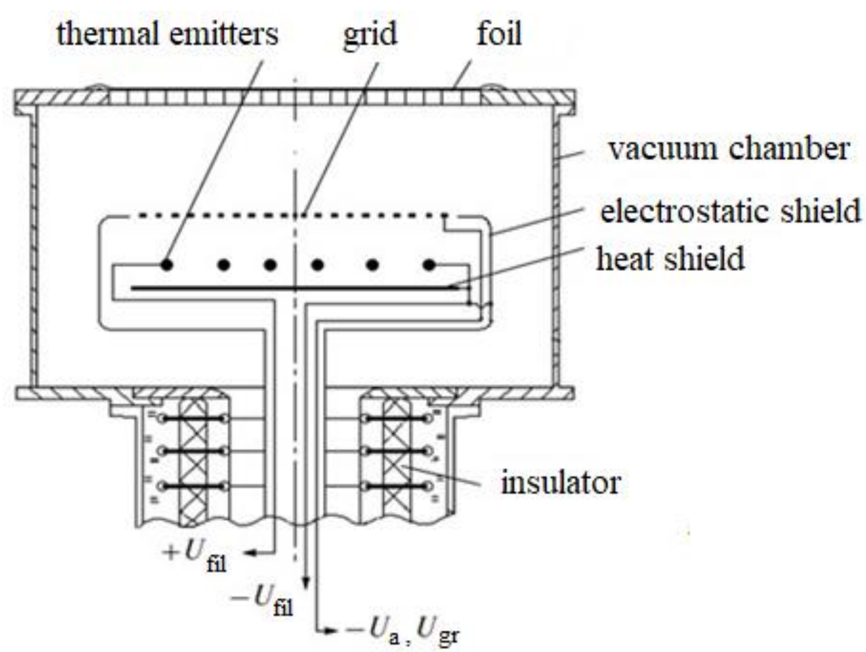


Fig. 2- The electron accelerator with thermionic cathode

Relevance

Application examples of electron accelerators with large cross section beams:

- *Food radiation processing;*
- *Sterilization of medical products;*
- *Pumping gas lasers;*
- *Curing of polymer coatings;*
- *etc.*

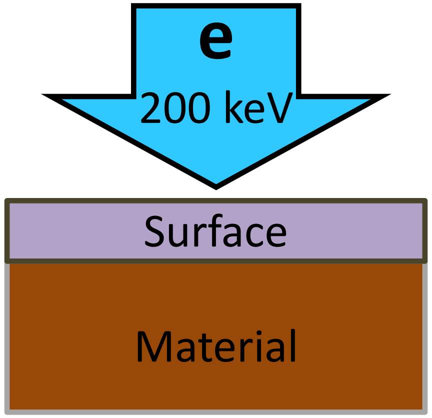


Fig. 3- Impact of a low-energy beam on the material surface

The purpose of this research work

To determine the fundamental possibility of a wide-aperture electron accelerator based on secondary ion-electron emission with a plasma emitter <u>in a pulse-periodic mode at an electron beam generation frequency of tens of kilohertz and its average power of a few kilowatts</u>.

Secondary ion-electron emission

<u>Ion-electron emission</u> is electron emission from the surface of a solid when it is bombarded with ions.

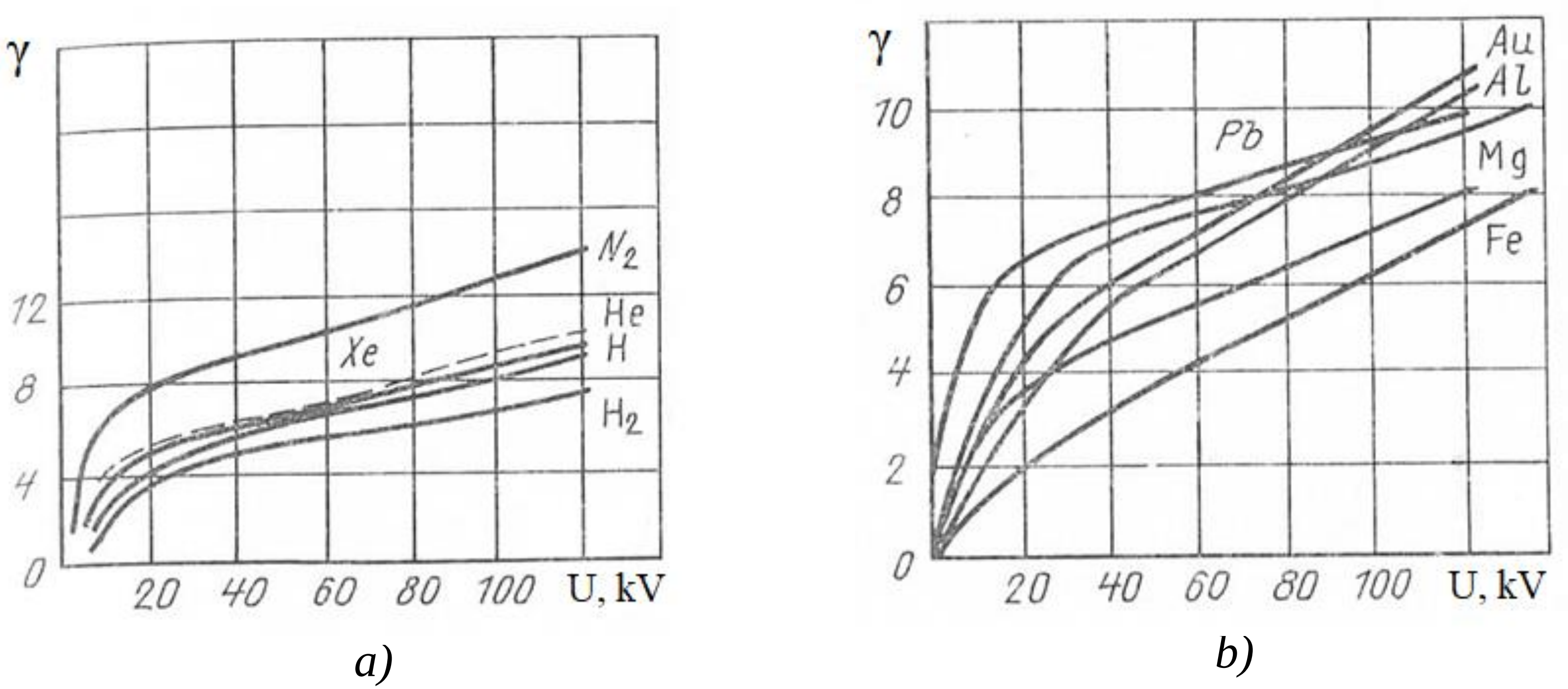


Fig.4 – Dependence of ɣ (U) on the type of gas and substrate material
a) aluminum substrate; b) *He* ion bombardment

Operation scheme

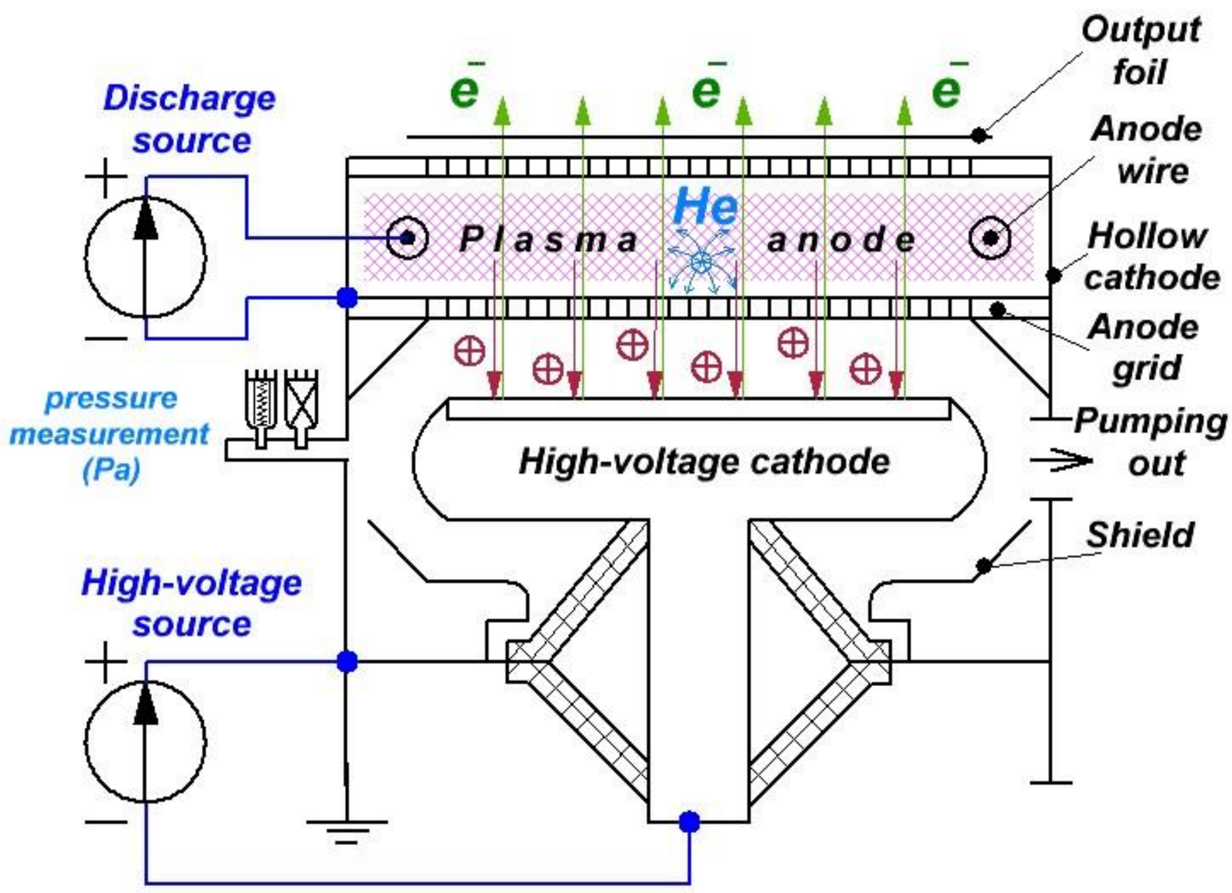
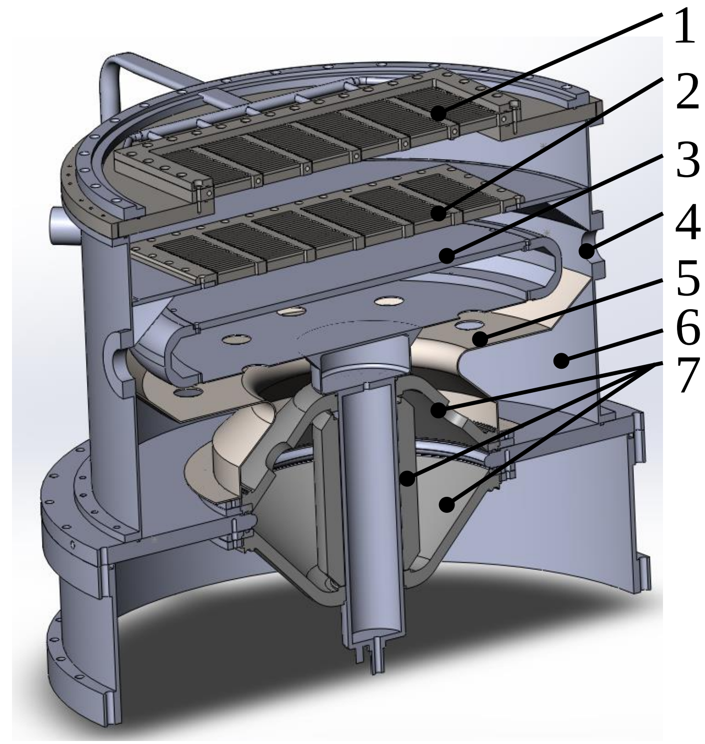


Fig. 5 — The operation scheme of an electron accelerator based on ion-electron emission

Design and parameters of the accelerator

Fig. 6 — Appearance, design and parameters of the accelerator



1 – Output foil window;
2 – Anode grid;
3 – Cathode;
4 – Pumping out window;
5 – Shield;
6 – Vacuum chamber;
7 – Insulators;

Electron energy	**up to 150 keV**
Current in the accelerating gap	**up to 100 mA**
Beam dimension	**400x650 mm**

Current-voltage characteristics of an auxiliary discharge at continuous mode

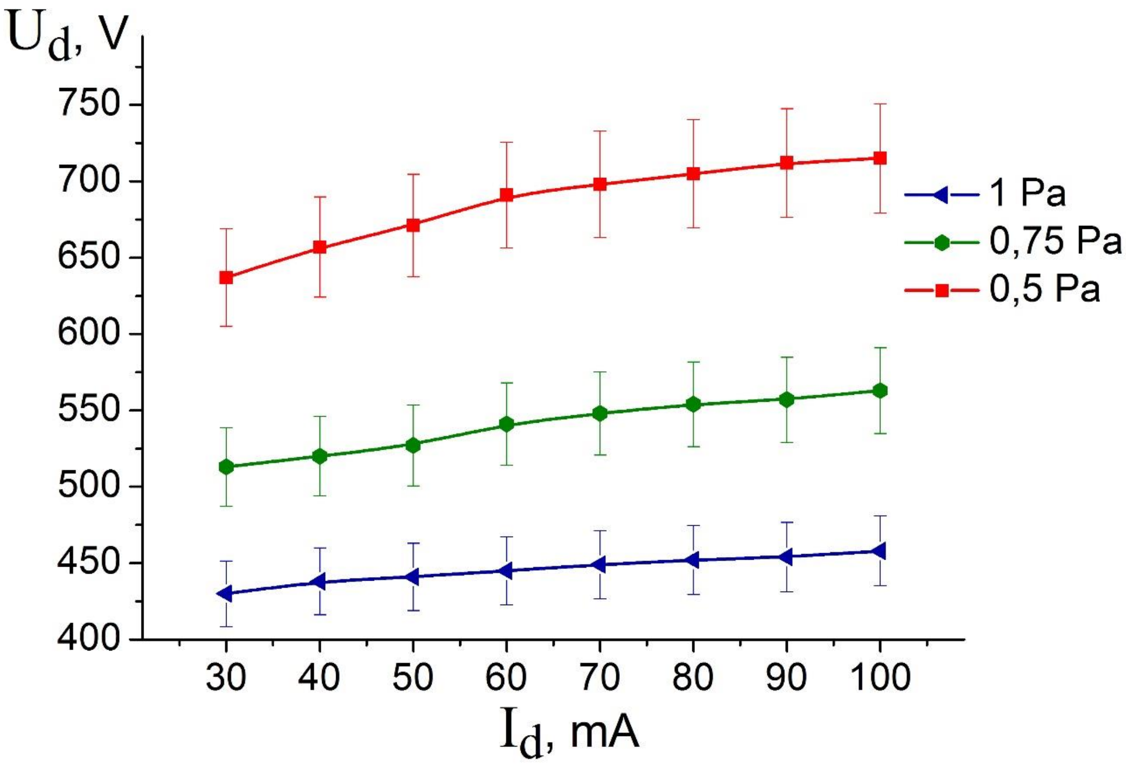
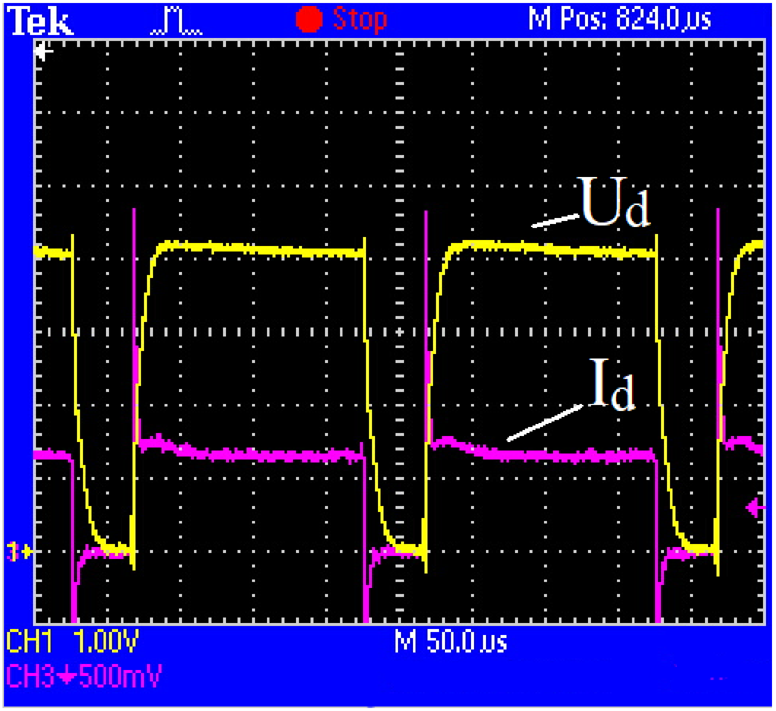
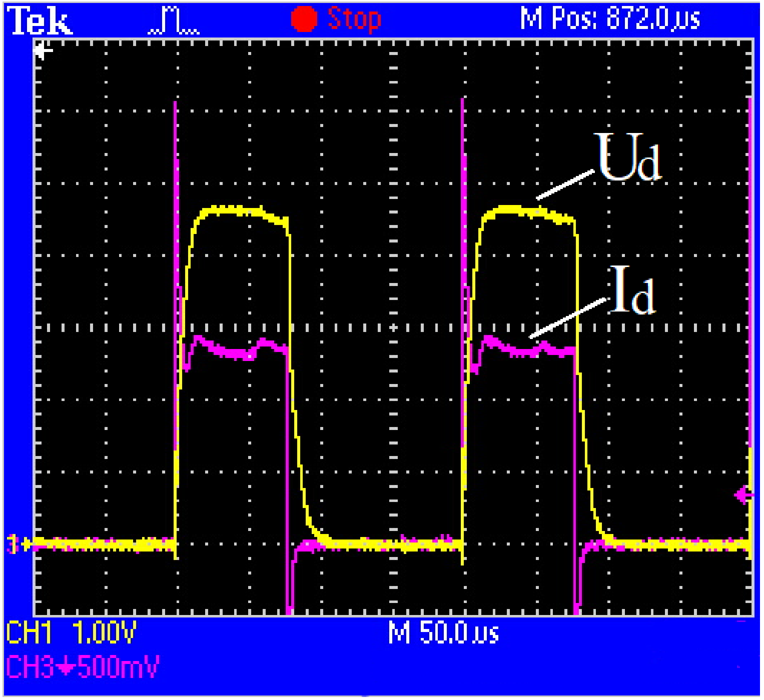


Fig. 7– Current-voltage characteristics of an auxiliary hollow cathode glow discharge at different He pressures

Auxiliary pulse discharge



D = 80 %



D = 40 %

Fig.8 – Oscillograms in the pulse-periodic mode (f = 5 kHz; $I_{av.total}$ = 50 mA):
CH1- discharge voltage (140 V/div);
CH3- discharge current (50 mA/div).

Current-voltage characteristics of an auxiliary discharge in continuous and pulsed mode

$$I_m = I_{av.total} / 2D$$

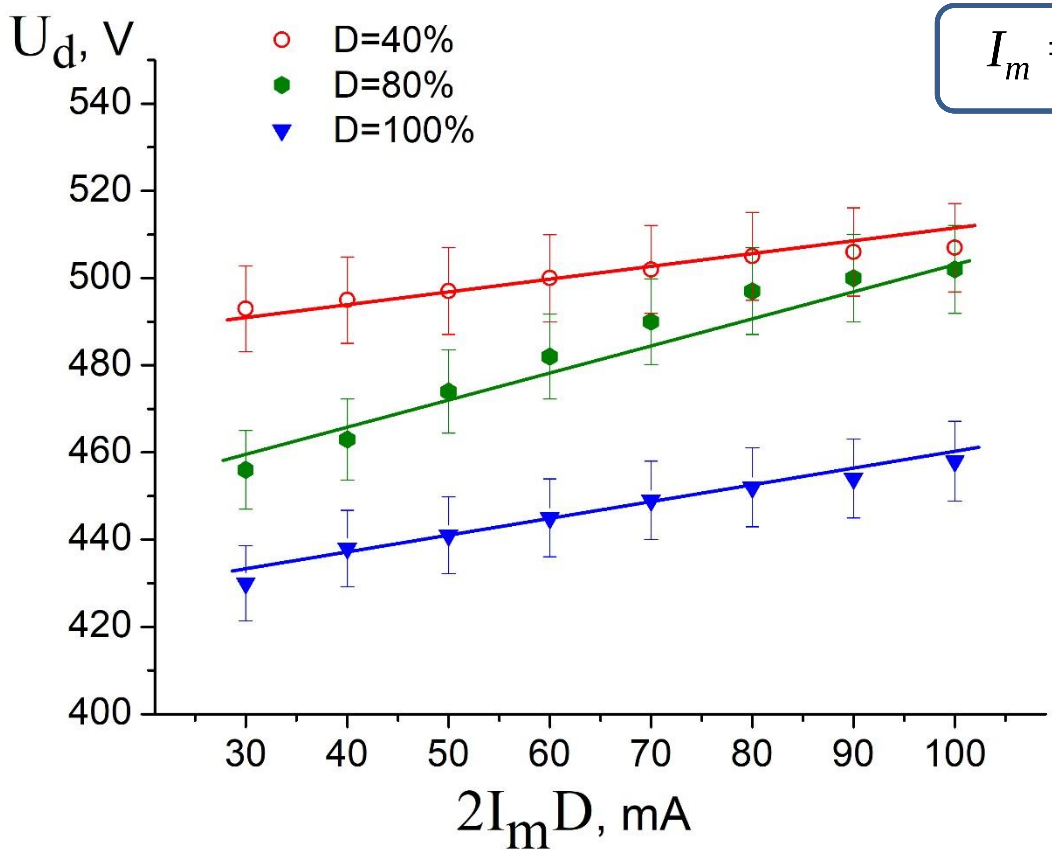
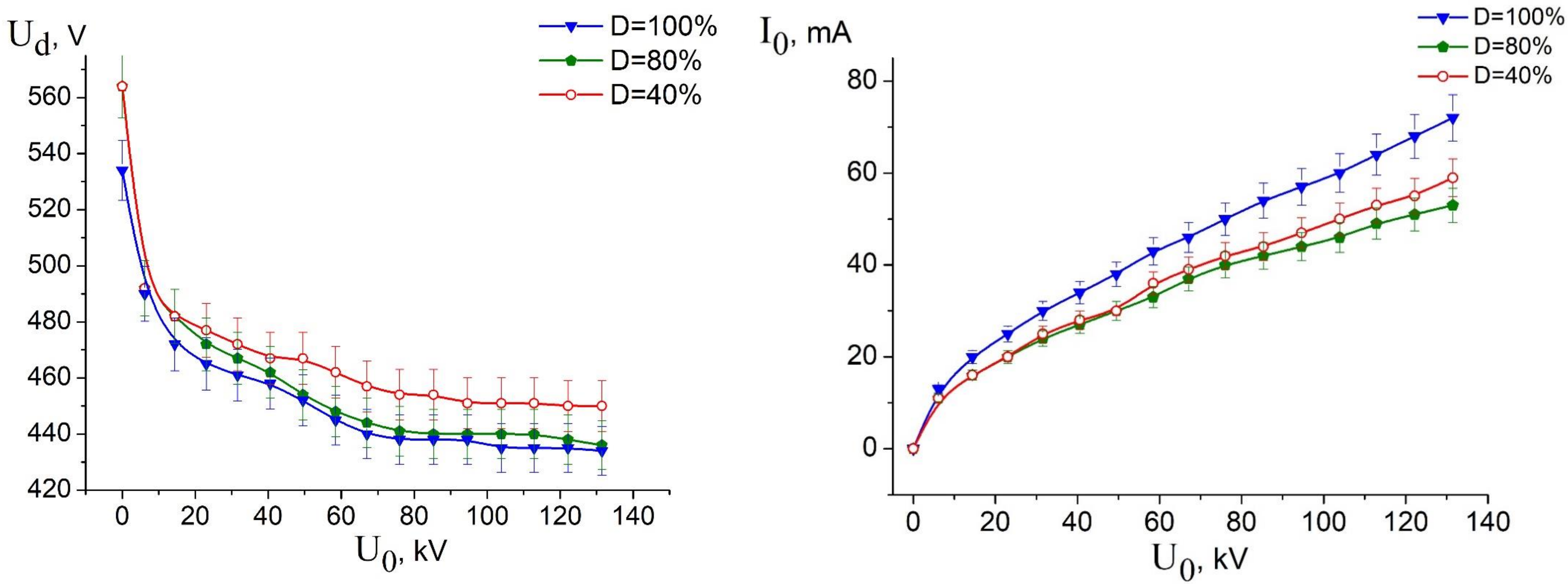


Fig. 9– Current-voltage characteristics of an auxiliary hollow cathode glow discharge at different modes

Dependences on accelerating voltage



a) *b)*

Fig. 10 —Dependences of discharge voltage U_d, (a) and current in the accelerating gap I_0 (b) on accelerating voltage value U_0 for different discharge modes (D=100; 80; 40 %)
f = 20 kHz; $I_{av.total.}$= 50 mA, p= 0.75 Pa

Conclusion

- *The current-voltage characteristics of the auxiliary glow discharge are determined in both continuous and pulsed operation modes of the discharge power source.*
- *Was performed launch of an electron accelerator based on ion-electron emission with 400x650 mm^2 in section at pulse periodic mode with average power of a few kilowatts.*

Plans for the future

- *Carry out research on control of the emission plasma boundary when operating in the pulse-frequency mode to determine a more efficient extraction of such an electron beam into the ambient atmosphere*

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Thank you for your attention!

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