Inverse semiplanotron ion source

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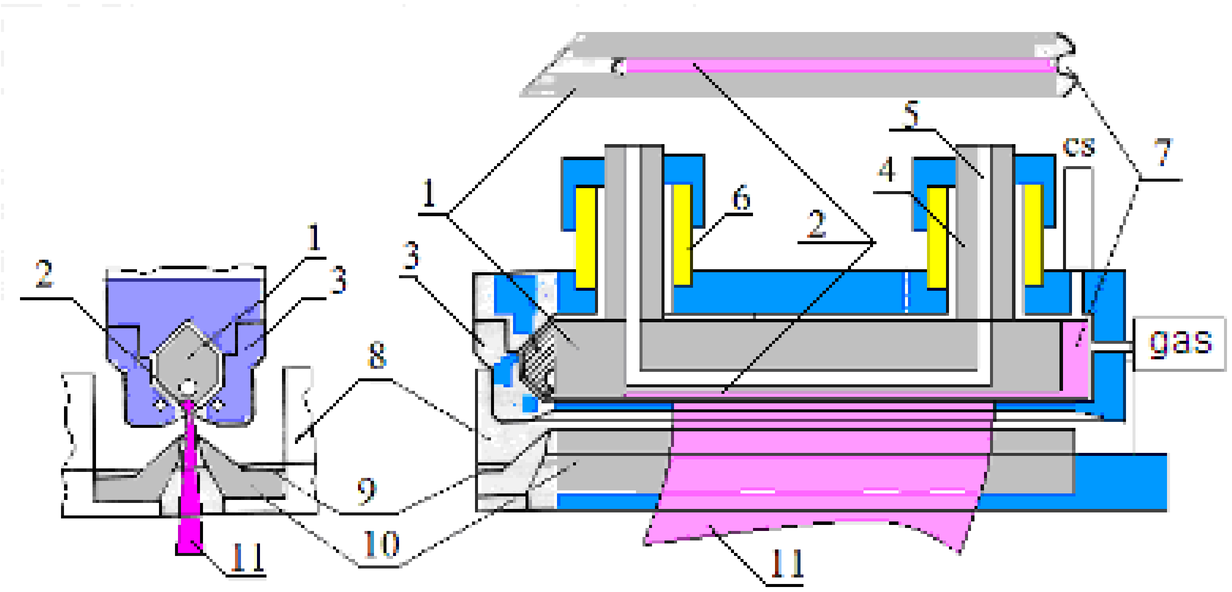
Abstract **The efficient geometrical focusing of negative ions was demonstrated in the SPS with semiplanotrons discharge configuration. Similar ion source can be used for positive ion production. But more efficient positive ions can be generated in inverse semiplanotron, which will be described below**

The generation efficiency of negative ions beams could be significantly increased by geometric focusing of the negative ions produced. For the first time, effective geometric focusing was accomplished in the SPS that we called the semiplanotron. A shematic of the first semiplanotron is shown in Fig. 1.

Fig. 1. Schematic of the first semiplanotron



. 1 – cathode, 2 – semicylindrical groove, 3 – anode, 4 – cathode holders, 5 – cooling channel, 6 – cathode insulators, 7 – recess for discharge ignition, 8 – magnet pole, 9 – magnetic insert, 10 – extractor, 11 – H^- beam.

The geometric focusing scheme is illustrated in Fig. 2. Negative ions emitted by a cathode are accelerated in the near-cathode potential drop along a normal to the surface. If the surface is cylindrical or spherical, negative ions are focused to the center of curvature. In experiments on the degree of focusing, one could judge by the sputtering trace on the anode. With transverse dimension of the groove 3 mm, the etched track had a width of 0.8 mm. The discharge voltage was typically 100 V.

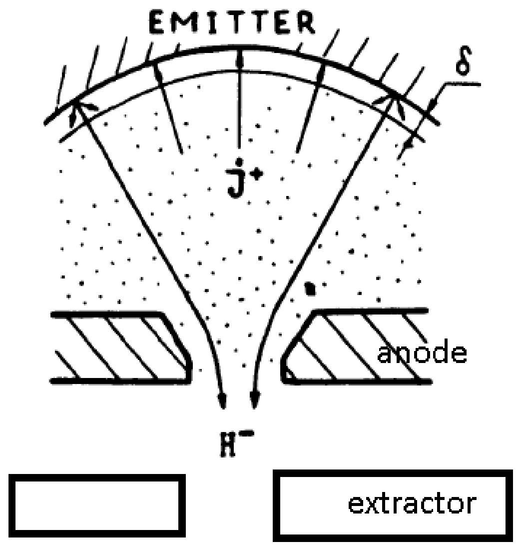


Fig. 2

. The dependence of H^- ion current and D^- ion current on discharge current for a number of emission slit dimensions is shown in Fig. 3. Beams of H^- ions are obtained with current up to 0.9 A for a discharge current of 100 A.

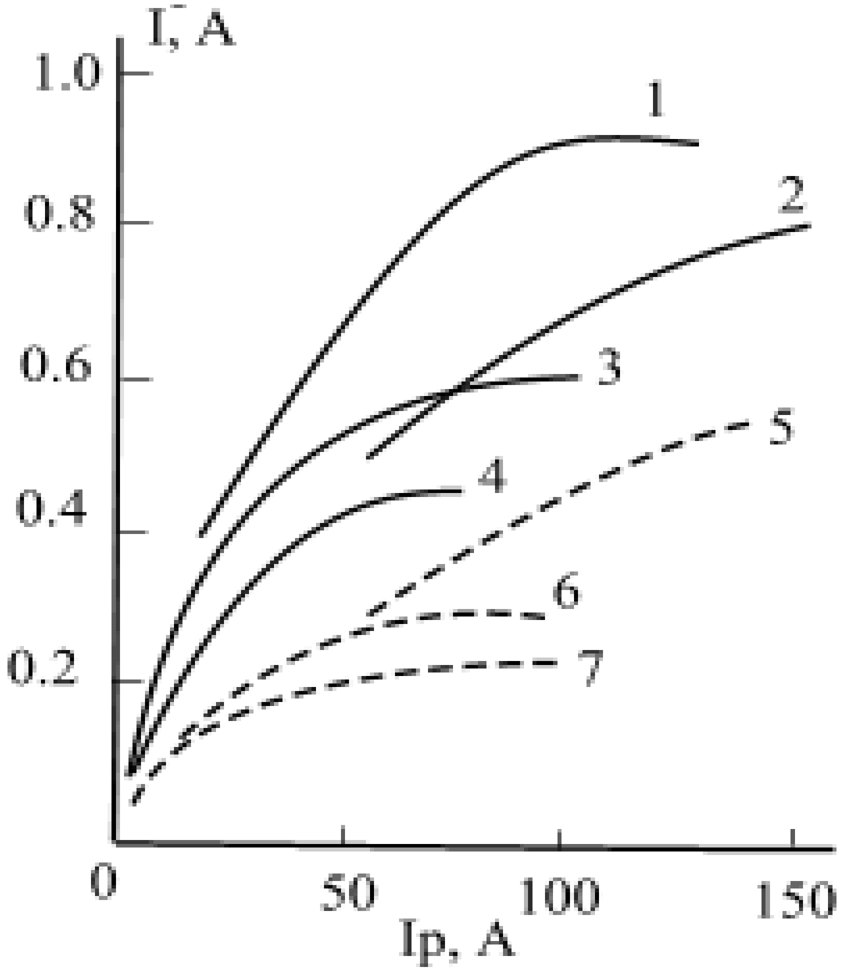


Fig. 3 H^- (1 – 0.72 x 45 mm^2, 2 – 0.5 x 41 mm^2, 3 – 1 x 40 mm^2, 4 – 1 x 20 mm^2), and D^- (5 – 0.5 x 41 mm^2, 6 – 1 x 40 mm^2, 7 – 1 x 20 mm^2).

Fig. 4 is illustrated a schematic of inverse semiplanotron design..

A cross section along magnetic field is shown in left part of Fig. 4and in right part is shown the cross section along emission slit. The inverse semiplanotron consist of an anode (1) and anode holders (4) which are insulated from a ferromagnetic cathode (source body) (3) by ceramic insulators (6). The bottom site of anode (1) has a flat surface (2) (~4-5 mm width) located opposite a long, narrow emission slit in the cathode (3). Magnetic field crossing a discharge gap between anode flat surface (2) and emission slit (9) is created by permanent magnet (8). The discharge is supported by voltage between anode (1) and cathode (3). The positive ion beam (11) is extracted from the discharge by high voltage applied between the cathode (3) and extraction/suppression electrodes (10). An empty part of cathode (7) is used for simplifying of the discharge triggering at low gas density.

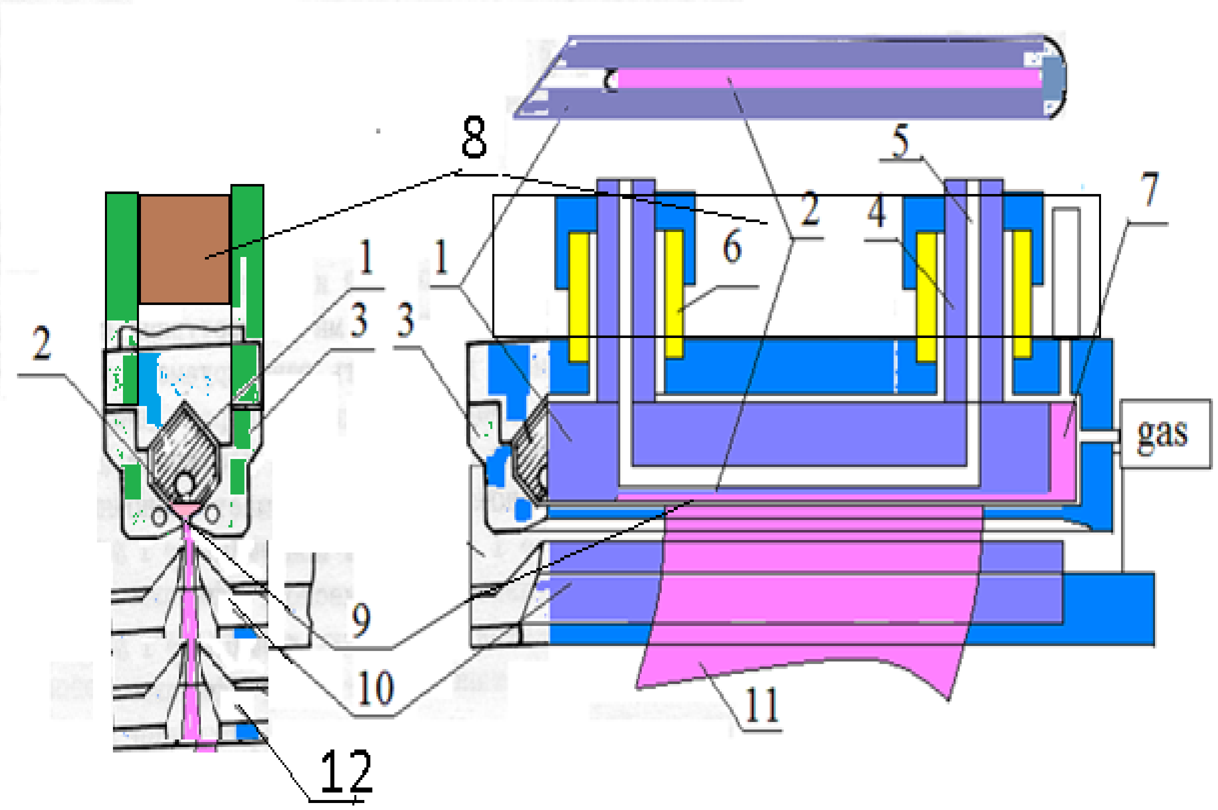


FIG. 4. (Color online) Schematic of the inversed semiplanotrons design.
1-anode, 2-flat part of anode,3-cathode body, 4-anode holder, 5-channel for anode cooling,6-ceramic insulator, 7-gap for discharge igniting, 8-permanent magnet, 9-emission slit, 10-extraction-suppressuin electrode, 11-ion beam, 12-grounded extractor.

Channels (5) in the anode and channels in the cathode are provided for cooling by gas or water. The cathode is made from ferromagnetic material, the anode is from stainless steel or molybdenum.

A three-electrode accel-decel extraction system of inverse magnetron as shown in Fig. 5 was optimized for low energy beam production and efficient space charge compensation. For simulation and optimization of the extraction geometry was used the simulating program PBGUNS. This code has been well tested, simultaneously determined the shape of the meniscus at the plasma boundary to include the effects of plasma density together with the effects of space charge within the beam as the extracted ions accelerate through the extraction region. Space charge compensation at the 99% level is assumed behind the suppresser electrode. Extracting and suppressed electrodes could be precision moving for optimization of beam formation at different energies

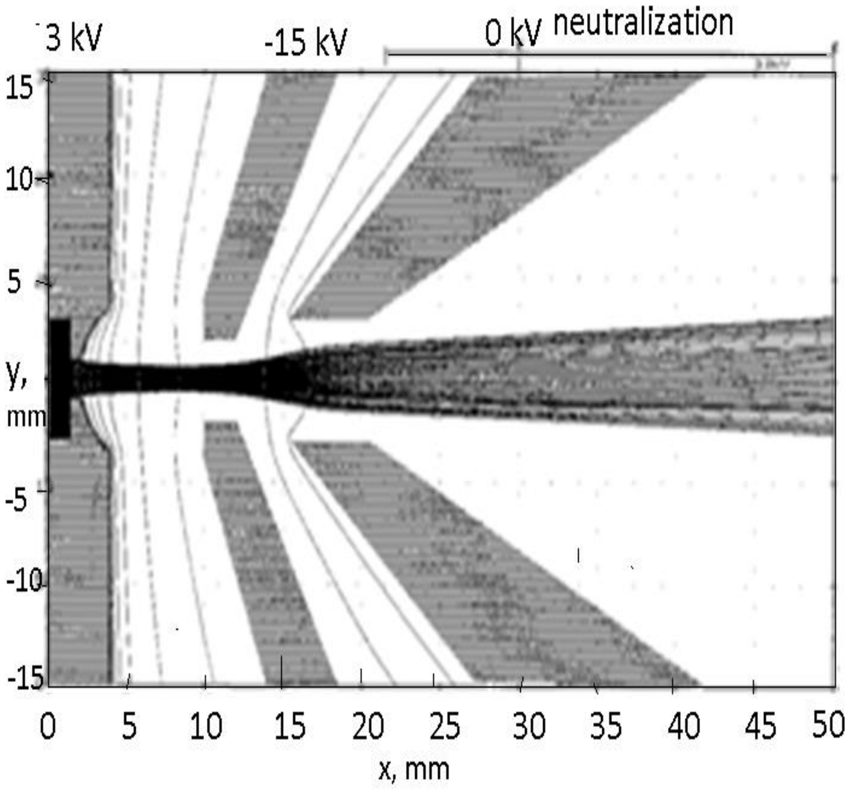


Fig. 5. Schematic of tree electrode extraction system of inverse magnetron energy ion source

The inversed semiplanotron with emission slit 3x150 mm^2 was fabricated and tested.
T he inverse semiplanotron was tested in pulsed mode of operation. The discharges with repetition of 10 Hz and duration of 1 ms was supported by forming line of ~10 Ohm impedance with a thyristor switch. The extraction voltage was varied up to 10 kV. The ribbon ion beam was registered by a Faraday cup in distance ~15 cm from the grounded electrode. The linear current density distributions were registered by the moving collector with a narrow slit. Dependence of ion beam current I on discharge current Id in discharges with hydrogen is shown in Fig. 6. A discharge voltage in discharge with hydrogen was 0.2 kV. Beam current 0.2 A was produced at discharge current ~5 A.
Different shapes of the emission slits were used for H+ beams extraction.

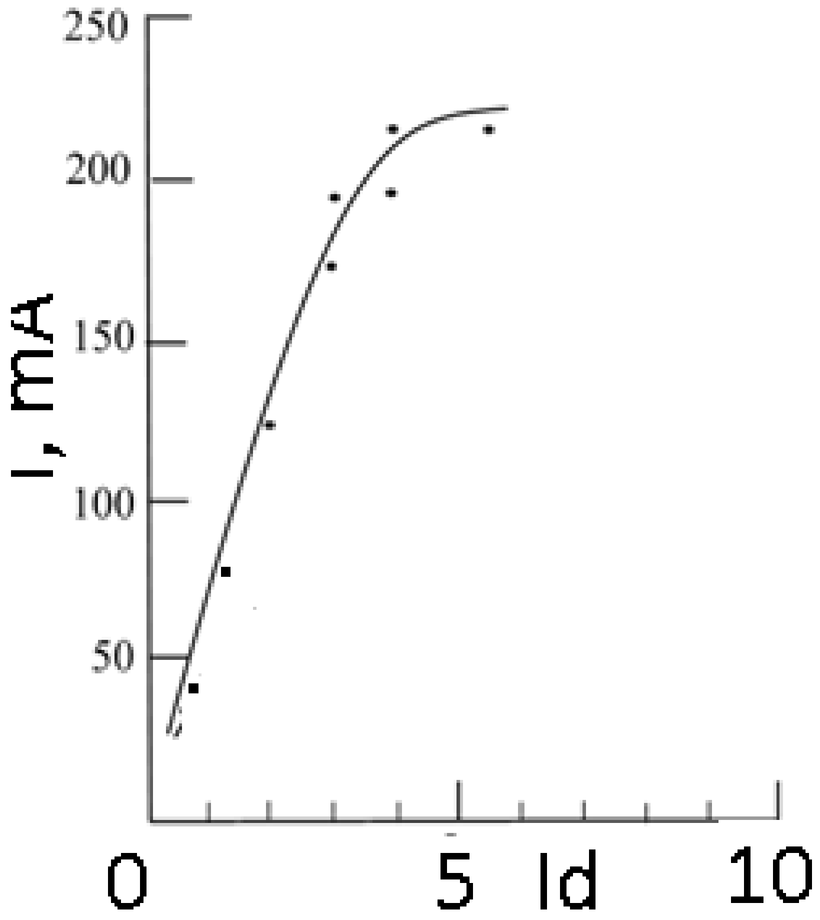


Fig. 6. Dependence of ion beam current on discharge current

It have been tested a work of the inversed semiplanotron in continues operation mode with heavy gases: argon, air, oxygen, nitrogen, propane, acetylene, water vapor and some gas cocktails. Gas flux in this case was controlled by needle lick. Deposition of insulating diamondlike film was observed after operation with gas propane. This deposition was removed by discharge operation with oxygen. The discharge voltage with these gases was ~0.3 kV. Efficiency of ion generation with heavy gases was little higher then, with hydrogen A specific discharge current is up to Jd~ 50 mA for 1 cm of the slit, generated the specific ion beam current is up to Jb= 30 mA for 1 cm of the slit.

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