HIGH INTENSITY HEAVY ION INJECTOR T-5010

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1 GENERAL DESCRIPTION

The newly developed 10 mA, 50 keV heavy ion injector T-5010 is intended for use in isotope separators, ion implanters as well as autonomously for researches in the physics and technology of ion sources. It is complete with power supply, control, vacuum and cooling system.

The injector layout is shown in Figure 1. The Freeman type ion source with four-electrode accel/decel system is set on the vacuum chamber /4/ equipped with movable Faraday cup for total beam current measurement. Two 950 l/s turbomolecular pumps are used for high vacuum pumping out. The injector power supply system is mounted in high voltage rack /10/ and control rack /1/. It is based on 50Hz/16kHz frequency conversion to provide the decrease of both size and weight of equipment. The 50kV, 20mA capacitive cascade generator /6/ is used as an accelerating voltage source. Ion source power supply, 25kV extracting voltage source and gas inlet system are mounted inside high voltage terminal /10/. The 16kHz insulating transformer with 50kV cable made secondary winding provides 3kW electric power transmitting to high voltage terminal.

The optical/electronic converters with fibre optic cables are used for remote control and measuring the ion source parameters. All the power supply units are stabilized.

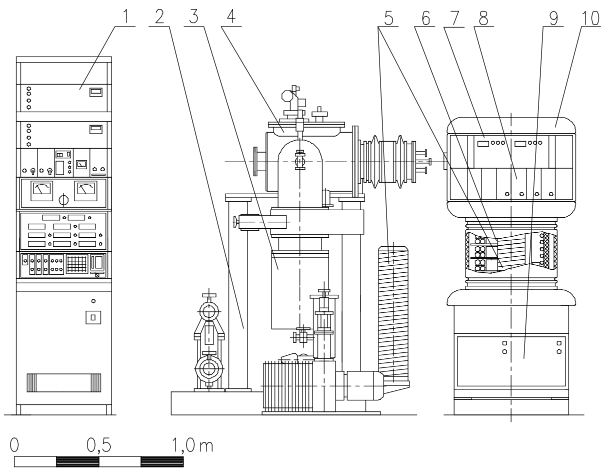


Figure 1. Injector layout

2 ION SOURCE

The Freeman type ion source [1, 2] is one of the most appropriate for use in ion implanters and separators till now. Its several variations [3, 4] are widely used in different facilities. The M-301H source developed is Freeman type one combined with four electrode extracting accel/decel system. [5]. Such a system provides the possibility of extracting voltage control at a fixed ion energy, it reduces beam divergence at the outlet and decreases the probability of high voltage breakdown in extraction gap. Assembly drawing of the source is shown in Figure 2.

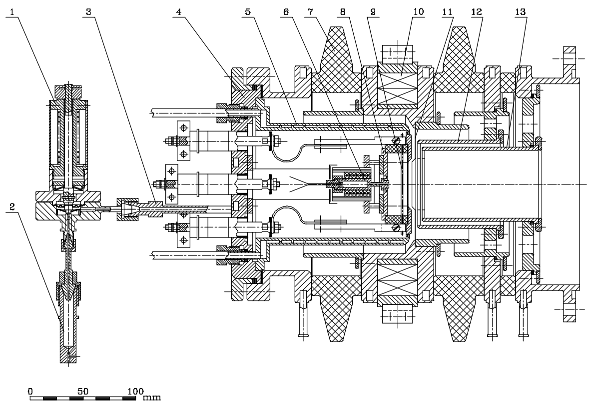


Figure 2. M-301H source assembly drawing.

The anode flange /4/ is at the high voltage terminal potential (+5 ÷ +50kV relative to ground) which determines the beam energy. Wide energy range is provided by adjustment of extracting electrode /11/ potential (0 ÷ --25kV relative to anode).

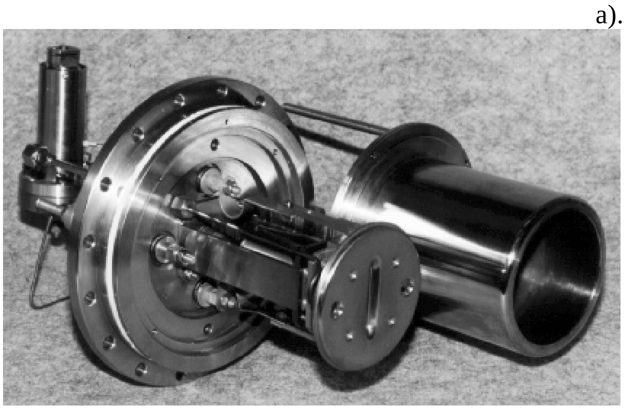
The directly heated 2mm in dia. W-Th or W-La cathode /9/ is fixed by NB insulators. The optimum cathode current is 120÷150A. The magnetic field is 0.01÷0.012T in value along the discharge chamber is supplied by external magnets /10/ mounted on the extracting electrode flange. To avoid use an additional 25kV insulating transformer the permanent magnets were employed. The design of the source allows use gas, liquid and solid charge material. The molybdenum anode arc chamber /8/ has three inlets - one for feed or support gas, another for vapor from outside container /2/ filled with liquid or solid which requires low temperature to receive necessary vapor pressure, and third one is connected with inside high temperature molybdenum oven /6/. The gas is fed through two-channel piezo-electric flow controller. The all-metal dosing valve with minimum dead volume /1/ has been developed for vapor flow control from outside container. The difference in thermal expansion coefficients of stainless steel and kovar are used in the valve to leak control. It is supplied with heater; operating temperature can be adjusted in the range of 50÷300^{0}C. The 300÷1200^{0}C inside oven temperature range is provided by means of heating, shielding and thermal gradient.

The water cooled electrode /5/ serves as high voltage- and heat shield, it is also protect the extracting ceramic insulator /7/ from feed material covering and, that is important, it is prevent the emission electrode from radial displacement in wide temperature range.

Ions are extracted through 40mm sleet in anode. The sleet width is defined by the molybdenum lips inserted between anode and disk molybdenum emission electrode and it is in the 0.5÷2.5mm range. The ion source and the accel/decel system are made as a structurally integral unit. The EFA-Plast thermoresistant glue is used for metal-ceramic connecting.

Photograph of the ion source is shown in Fig. 3.

a).



b).

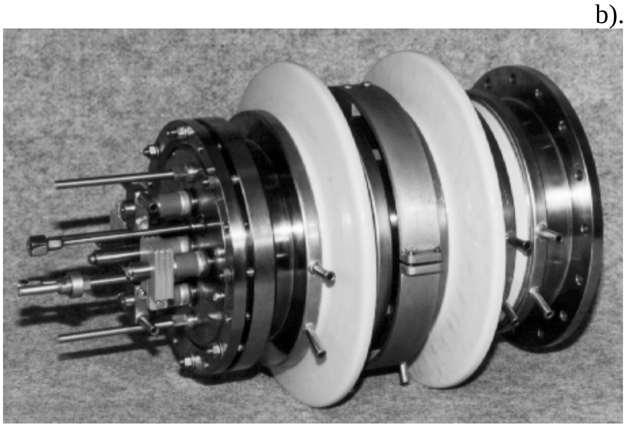
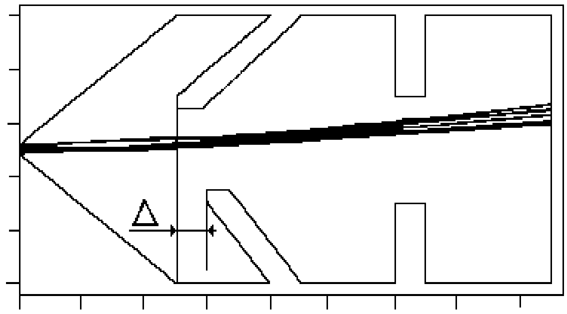


Figure 3. M-301H ion source
a). disassembled, b). completed with accel/decel system

The absence of high voltage electrical feedthroughs in the source provides its more reliable operation.

The computer simulation was used to optimize the configuration of extracting system. The method of finite element was chosen to solve the Poisson’s equation. The calculation of electric field strength, ion beam trajectories and the space charge was carried out for partial and full beam space charge compensation.

a).



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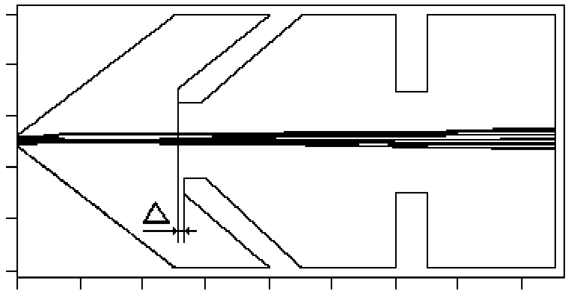

Figure 4. Ion beam trajectories.
I_{beam}=10mA, E=40keV, M=40AMU
a). B=0, Δ=1.0mm; b). B=0.01T, Δ=0.2mm,

The different from conventional way to compensate the transverse angular deflection of the beam due to ion source magnetic field have been applied. We proposed to use longitudinal displacement of the extracting electrode slot edges relative each other to form the appropriate asymmetry of electric field in the extraction gap. Figure 4 shows the relative influence of both magnetic and electric fields on beam deflection for such a system. The computer simulation allowed to optimize the “lopsided” configuration of extracting electrode for different ion species. Several changeable extracting electrodes with different displacement are enough for all practical cases.

3 PERFORMANCE

Photograph of the T-5010 injector is shown in Figure 5. The injector systems testing has confirmed the correctness of main technical solutions applied. The preliminary investigations of the injector characteristics in various regimes of operation have been performed. For 40-50keV beam energy the total beam current s was about 15mA and current density 20÷30mA·cm^{-2} when working with gas (N_2, Ar), liquid ($TiCl_4$), and solid (Sb). The discharge current was not exceeded 3A. The appropriate thermal gradient between the different parts of ion source and sufficient shielding of ceramic insulators was provided thus resulting in quite stable

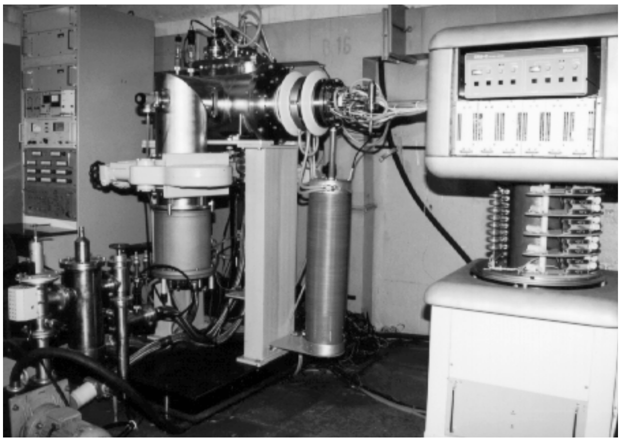

Figure 5. T-5010 injector under testing.

operation of the injector. and extracting system.

Testing of the transverse beam deflection at the injector outlet for different ion species and several values of the extracting electrode slot sizes displacement confirmed the numerical simulation result.

4 REFERENCES

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