ION SOURCE OF DISCHARGE TYPE

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Abstract

A new scheme of ion source based on a dielectric surface sliding discharge is described. The conditions to form this type of discharge are analyzed and experimental results are shown. The main parameters of this ion source are: accelerating voltage $U = 1 - 20$ kV; continuous extracted ion beam; current density $j = 0.01 - 0.5\,\mathrm{A/cm^2}$; ions of Cl, F, C, H; residual gas pressure $P = 10^{-6}$ Torr. A magnetic system is used to separate the different types of ions. The dielectric material in the discharge circuit (anode plasma emitter) defines the type of ions. The emission characteristics of plasma emitter and the discharge parameters are presented. The ion current yield satisfies the Child-Langmuir law.

1 INTRODUCTION

The development of different kind ion sources is going intensively nowadays. It is connected with a number of problems concerning the forming of the plasma - the ion emitter in known ion sources. Discharge schemes based on gas discharges are used to get continuous ion beams. Many difficulties exist in the production of the ions of the dielectric materials due on the demand to form a plasma which components are the ions of needed kind. In this article it is suggested to use a sliding discharge [1] on the dielectric surface for receiving of continuous ion beams of: carbon, chlorine, fluorine, hydrogen etc. from different dielectric materials

2 CONSTRUCTION AND SCHEMATICS

The ion source, shown schematically in Fig. 1, consists of two main blocks. The first one is the discharge block, formed by dielectric body 1, with a dielectric ring 2 connected to the body 1. On the surface of ring the 2 sliding non-finished discharge is ignited by the voltage, applied to the grid electrode 3. The second block is for extraction of the ion beam. It consists of a ring-shaped isolator 4 and high voltage electrode 5. The voltages igniting the discharge and extracting the ion beam are fed through vacuum sealed connectors 6 of the flange 7. The whole construction is enclosed in a vacuum chamber which may be connected to an external system by a flange. The main(principal) element of the discharge device is the dielectric ring. From the opposite to the grid electrode 3 side of the ring there is a contact electrode from copper or other conductive material. This contact electrode, as well as the grid electrode, may be attached to the dielectric surface of the ring by evaporation or other electro-chemical technique. For dielectric surface discharge stabilization an external magnetic field, produced by a permanent magnet, is applied. The ion charge/mass state separation is fulfilled also by the magnetic field of permanent magnets, changing appropriately the distance between the magnets by a mechanical device. The ion source may be powered by one of the next supply schematics, shown on Fig. 2. Residual gas pressure in the source is $10^{-6} \div 10^{-5}$ Torr. The ion source is not complicated . It may be produced and assembled easily and may be tuned quite fast.

3 PRINCIPLE OF OPERATION

The ion source principle of operation may be described as follows: by applying a voltage from the power supply to the discharge block a sliding discharge is formed on the dielectric surface between the contact and the grid electrode over the grid cells. This discharge becomes plasma ion emitter. The discharge forming depends on the electric field strength in this interval which by residual gas pressure in the above mentioned limits is 2×10^6 V/cm in average. Further processes in the plasma discharge consist in primary dusting and further disintegration of the dielectric material in the needed plasma components to reach the required current density. The upper level of the density is limited by the resource of the stable glowing of the discharge, connected to the dielectric erosion and the instability of the plasma discharge between the cells of the grid electrode.The experiments show, that for stable discharge, supported by discharge block voltage between 4 and 15 kV, best results are received with grid cell size from 1×1 to 2.5×2.5 mm $\times$ mm. The dielectric ring material determines ions type.To receive ions of fluorine the best is to use foil-covered teflon, of chlorine - vinyplast,of carbon or hydrogen -polyethylen,etc. Ion extraction is provided by electric field, formed in the ion beam extraction block, fed by dc high voltage supply source. The needed voltage is from 1 to 20 KV.

4 RESULTS

The emission characteristics of the described ion source show that the value of the extracted ion beam for different ion sort satisfies the Child- Langmuir law. By the above mentioned voltages on the extraction block the value of the current in the continuous extracted ion beam is from 0.01 to 0.5 A. The value of the ion current strongly depends on ion mass accordingly to the Child-Langmuir law.The measurements of the formed ions charge state in the source showed that it is equal to 1. At present study and work to increase the charge state are carried out.The source life time is limited by the time of stable discharge forming and reaches 6 hours in the best cases. Additional research and development work is needed to increase the ion source life time. This concerns first of all the dielectric ring parameters and the search for its most suitable components.

5 CONCLUSIONS

The presented source works on a new principle and allows the receiving of continuous ion beams from solid state dielectric materials with any wanted form of the beam cross-section. Additional work is needed to increase its life time and to determine its emittance parameters.

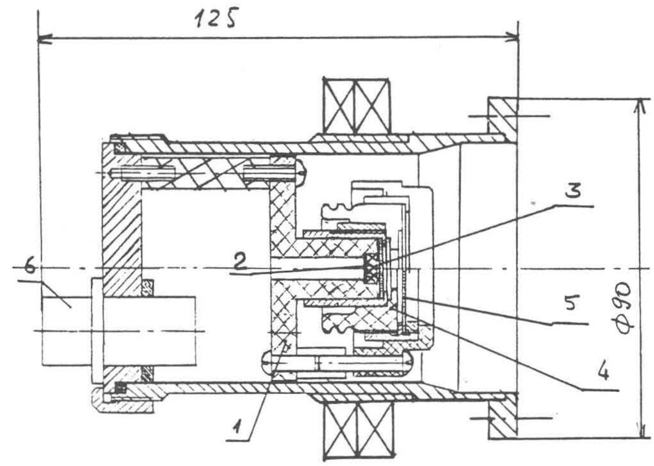

Figure 1: Ion source section

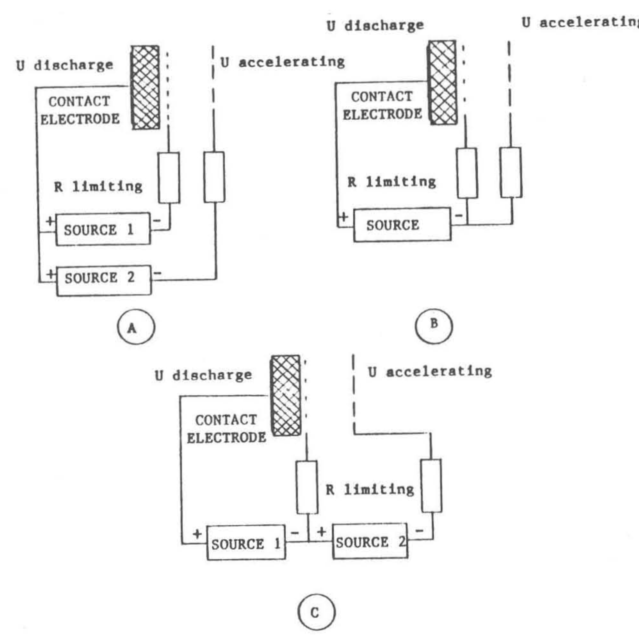

Figure 2: Power supply schematics

References

[1] Korenev S. A., Diode with a plasma cathode, based on sliding discharge, Print 9-82-758, JINR, Dubna, 1982