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A MODIFIED ELECTROSTATIC ION SOURCE OF A SADDLE FIELD CONFIGURATION

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The spherical ion source of a saddle field configuration has been modified by transforming the two hemispherical cathodes to two planes. Thus, a simple ion source is available. Optimal source dimensions, and the discharge and the output ion beam characteristics have been carried out experimentally. The results have shown that the modified ion source is more efficient than the spherical one.

1. Introduction

Cylindrical and spherical saddle field ion sources are of the cold cathode and oscillating electron type. These sources have been successfully used to ion beam machining, thinning and surface analysis. The characteristics and application of such sources have been described in a number of papers (e. g., Refs. 1, 2 and 3). Franks[4] has shown the saddle field configuration can be achieved by transforming the cathode cylinder and the anode rods of the cylindrical ion source to a sphere and an annulus, respectively. A compact spherical ion source was developed by these transformations which has produced a narrow intense ion beam.

This report shows that the transformation of the two hemispherical cathodes to two planes result in a more compact, efficient and simple ion source.

2. *Description of the modified ion source and the experimental apparatus*

A schematic diagram of the modified ion source and its associated electrical circuit is shown in Fig. 1. The source consists mainly of a stainless steel annular anode, two brass annular screens and two brass disc cathodes. Each cathode has a brass insert so that ion apertures of different sizes can be used. This also allows these inserts to be changed when they get damaged by continuous ion bombardment. The anode is isolated from the screens by two ceramic insulators.

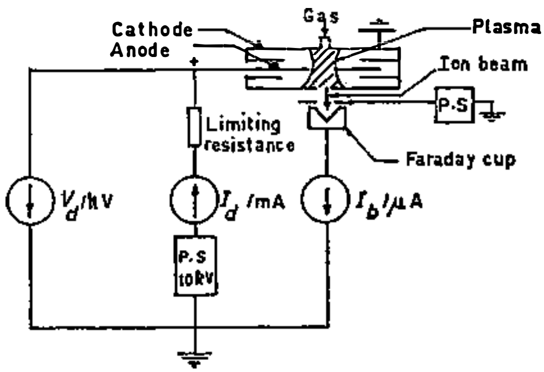

Fig. 1. The electrical circuit used for the experimental investigations.

All source parts are contained inside a stainless steel cylinder whose ends are the disc cathodes. The anode and the screen hole diameters are 5 and 9 mm, respectively. The anode-cathode spacing is 5.9 mm. Both the anode and the screens are 1.5 mm thick. Gas is admitted into the source through the aperture of one insert, for the best interaction between the gas and the oscillating electrons, while the other is used for ion beam extraction.

The source was tested in a stainless steel chamber pumped by a conventional oil diffusion pump and a rotary pump. The pressure in the chamber was measured by an ionization gauge.

As shown in Fig. 1 the anode is fed from a d. c. 10 kV supply, and the screens and the cathodes are connected to earth. The ion current is measured by means of a Faraday cup connected to a micrometer.

3. *Experimental investigations and discusssions*

3.1. *The effect of the screen hole diameter*

During these experiments the anode hole diameter, d_t, the anode screen spacing ($l_{s\text{-}c}$ which is the ceramic insulator thickness), the anode cathode spacing ($l_{a\text{-}c}$) and the ion exit aperture diameter (d_e) were fixed at 5, 2.5, 5.9 and 2.5 mm, respectively. The discharge voltage (V_d), current (I_d) and the ion beam current (I_b) were recorded at pressure (p) 3.6 $\times$ 10^{-2} and 2.9 $\times$ 10^{-2} Pa for four screen hole diameters (d_0) 7, 8, 9 and 10 mm.

The ion beam current was plotted versus the screen hole diameter at discharge powers (P) 2.5, 5, 7.5 and 10 W and for pressures 3.6×10^{-2} and 2.9×10^{-2} Pa as shown in Figs. 2 and 3, respectively. Each figure shows maximum ion beam current at 9 mm screen hole diameter. It seems that the oscillating electrons are more stable at this optimum value.

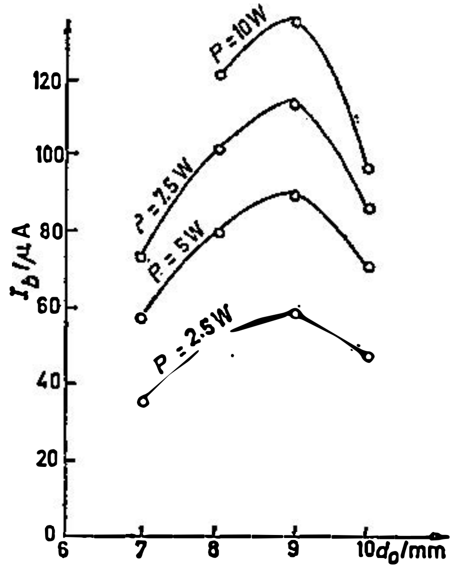

Fig. 2. The relation between the ion beam current and the screen hole diameter at pressure 3.6×10^{-2} Pa for anode hole diameter 5 mm.

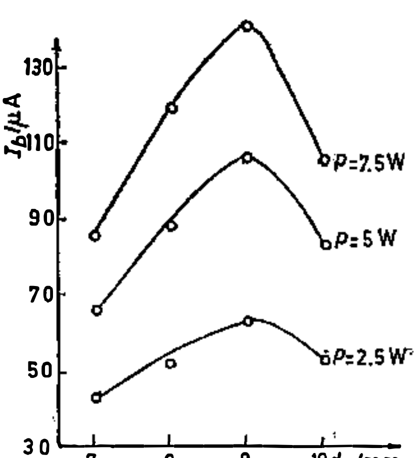

Fig. 3. The relation between the ion beam current and the screen hole diameter at pressure 2.9×10^{-2} Pa for anode hole diameter 5 mm.

3.2. *Discharge characteristics and the ion beam characteristics of the modified ion source*

These experiments have been carried out with the previously optimum dimensions but with 1.5 mm ion exit aperture diameter instead of 2.5 mm.

Figs. 4 and 5 show the discharge characteristics, the discharge current vs. the discharge voltage at various pressures, using nitrogen and hydrogen gases, respectively. These characteristics have the same general form as those of the spherical ion source[2].

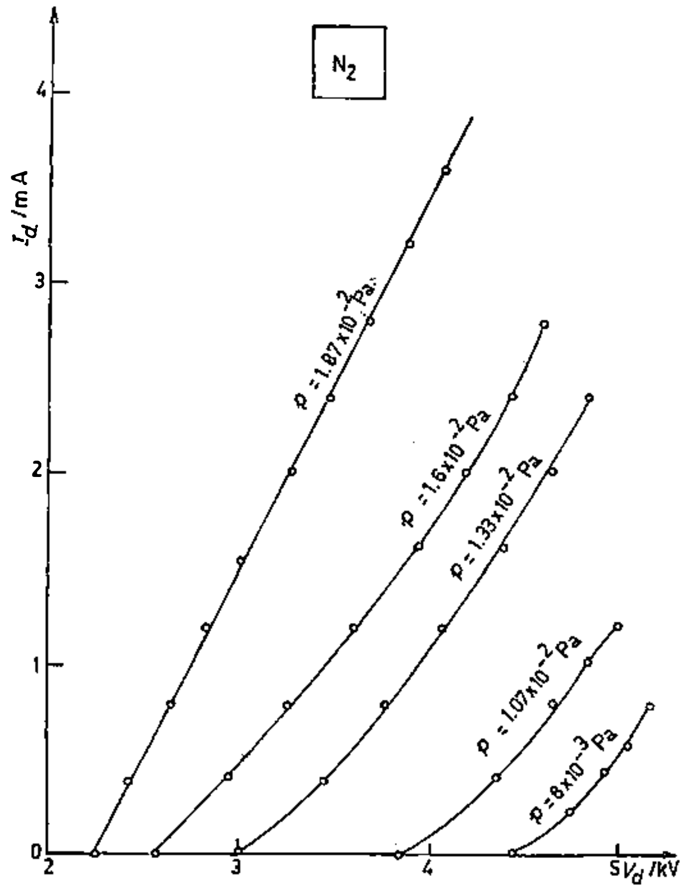

Fig. 4. Discharge characteristics of the efficient ion source for nitrogen gas.

The ion beam density (I_b/A), the discharge current (I_d) and the discharge voltage (V_d) as a function of the input discharge power ($V_d \times I_d$) at different gas pressures were illustrated in Figs. 6 and 7 for nitrogen and hydrogen gases, respectively. It is clear from Fig. 6 that, for a given discharge power, both of the nitrogen ion beam density and the discharge voltage increases with the decrease of the

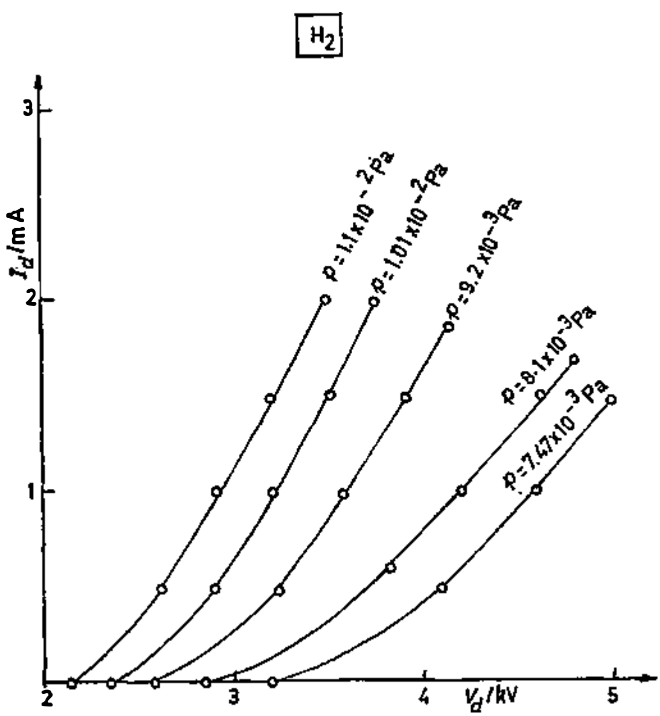

Fig. 5. Discharge characteristics of the efficient source for hydrogen gas.

pressure from 1.87×10^{-2} to 1.07×10^{-2} Pa. The maximum obtainable ion beam density without overheating the source is 4 mA/cm^2 at $P = 10$ W, $p = 1.87 \times 10^{-2}$ Pa and $V_d = 3.9$ kV. This value is approximately 1.7 time the spherical ion source[5].

4. Conclusion

The transformation of the two hemispherical cathode of the spherical ion source to two planes lead to obtain a simple, more compact and efficient ion source. This source can be used for many applications such as ion bombardment studies[6].

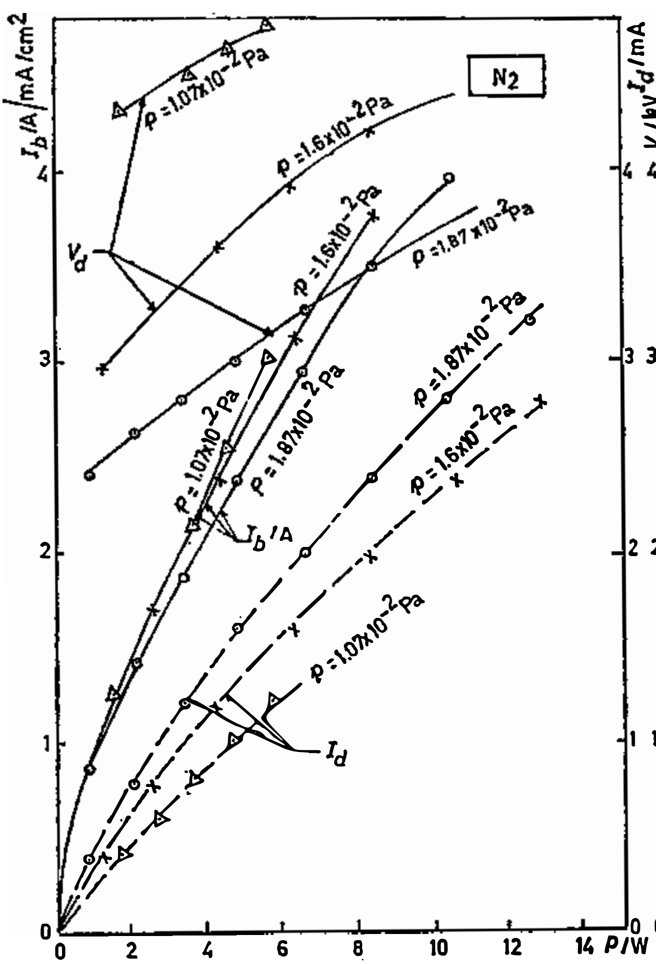

Fig. 6. The relations between the ion beam current density, the discharge voltage, the discharge current and the discharge power for nitrogen gas.

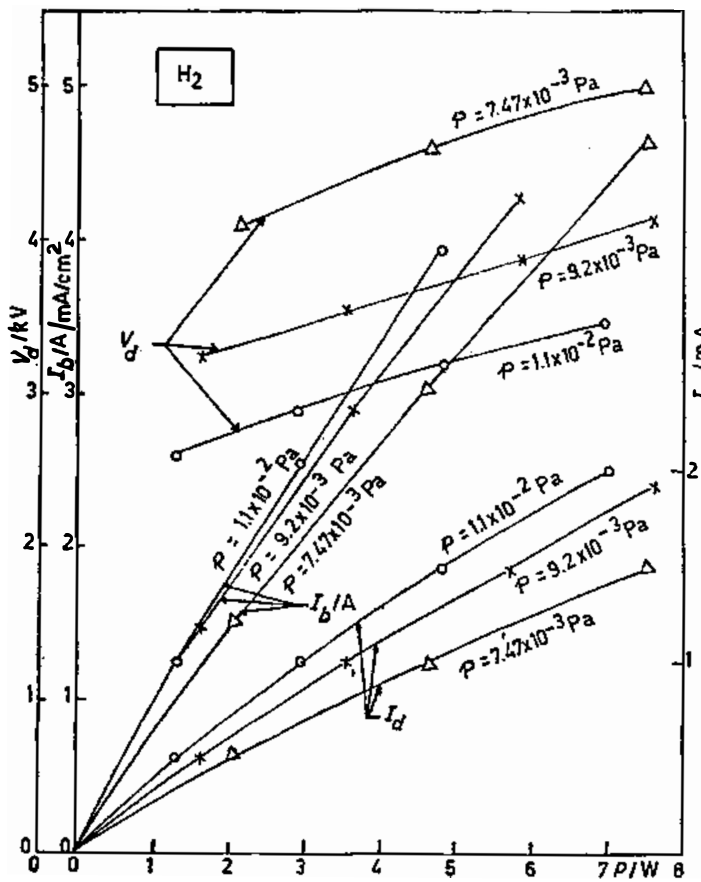

Fig. 7. The relations between the ion beam current density, the discharge voltage, the discharge current fnd the discharge power for hydrogen gas.

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MODIFIKACIJA ELEKTROSTATSKOG IONSKOG IZVORA SEDLASTE KONFIGURACIJE POLJA

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Sferični ionski izvor sedlaste konfiguracije polja modificiran je tako da su dvije hemisferične katode zamijenjene ravnim katodama. Tako je dobiven jednostavni ionski izvor. Optimalne dimenzije izvora te karakteristike izboja i izlaznog ionskog snopa određene su eksperimentalno. Rezultati pokazuju da je tako modificirani ionski izvor efikasniji od sferičnog.