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Visual Investigation of the Radial Energy Distribution of the Ions Produced by a Low Pressure Saddle Field Ion Source

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Abstract

A simple practical method is used to investigate the distribution of the positive ion in the beam produced by a low pressure saddle field ion source according to their energies. It was found that the more energetic ions are those in the central portion of the ion beam while the ion energy decreases radially toward the edges of the beam.

Keyword: Saddle field ion source; Energy distribution of the ions; Vacuum system; Thin film.

1. Introduction

The saddle field ion source is an oscillating electron ion source which was first described by [1]. It is a device which produced long electron path length and hence efficient gas phase ionization at low pressure with out a magnetic field or a thermonic source of electrons.

The source normally operates in the range (1- 0.1 m Torr) and produces an intense beam of positive ions. The cylindrical form of these low pressure cold cathode ion sources was first described by [2].

The three operation modes of the source were studied by [3], and it was observed that the oscillating mode (Chamber pressure is equal to $2x10^{-4}$ Torr) is the most convenient mode to produce a stable intense ion beam with a great source efficiency .

The main properties, characteristics, applications and construction of these sources have been described in a number of papers [1,2,3,4, and 5] . [6] utilized a cylindrical source type B 95 with a beam aperture of 75mm x 150mm for depositing Diamond-like Carbon (DLC) films for medical and bioengineering application . [7] pointed the main disadvantage of the cylindrical form of these sources and designed a spherical geometry by manufacturing the anode from a stainless steel annulus and the cathode from two aluminum hemispheres . Fig (1), shows a schematic diagram of this source ,after[8]with small changes, which was also the one used in this work . A modified version of this source produced by Ion Tech Ltd , known as fast atom beam (FAB),who claim that the FAB 11 beam is truly neutral and does not contain a mixture of ions , atoms, and electrons . The neutral contend of the beam for these sources has been determined over a range of conditions and found to vary from below 50 % to almost 100% [9].

[10] used a modified form of fast atom beam (B93) source which operates at a lower pressure than conventional cold cathode sources, for diamond like carbon film formation and to study the optical and mechanical properties of these films .

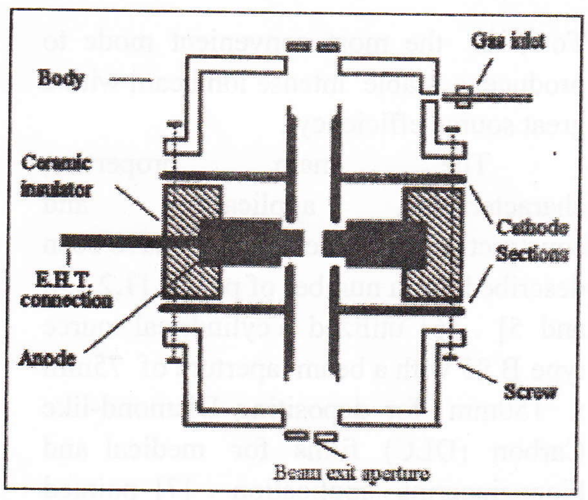


Figure (1): Schematic diagram of saddle field ion source.

Using different techniques, many authors (7,11 & 12) measured the ion energy produced by these sources and as an average it was nearly 80 % of the anode potential of the source. The purpose of this paper is to show visually the ions distribution within the beam according to their energies.

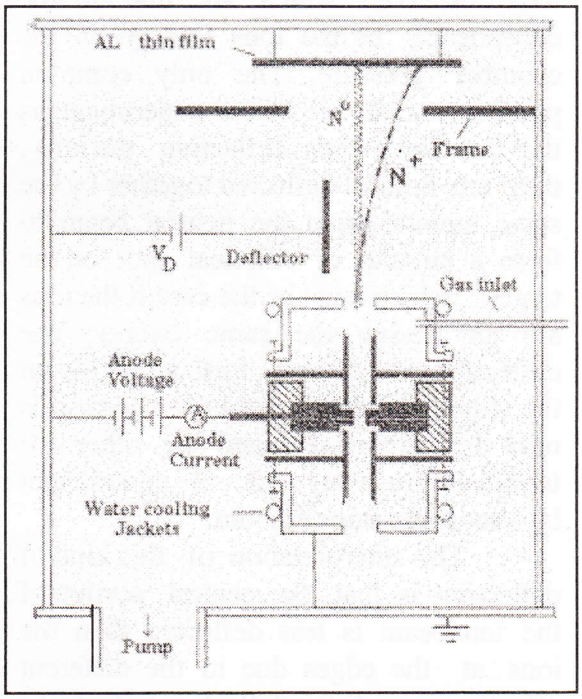
2. Apparatus and Techniques

A schematic diagram of the used apparatus is shown in the fig. (2) . The complete system is evacuated by a Vacuum system which is a Varian one , model 3317 ,it consists of a rotary pump and a water cooled oil diffusion pump , which gives a ultimate pressure of about 10^{-6} Torr .

The ion source used is a modified form B 11 source produced by Ion Tech Ltd. The stability of the source was performed by constructing a water cooling system to cool it .

The anode of the source is made of a stainless steel, 7mm thick with an aperture of 5mm diameter in its center , and the two cathodes were aluminum discs of diameter 11 mm and thickness 1.5 mm with ion exit aperture 1.5 mm ,through which similar ion beam emerged. The whole assembly is enclosed in an outer cylindrical Duralumin body of diameter 3.3 cm and length 2.2 cm .

The electric high tension (E.H.T){5.5 KV} connection to the anode emerged from the source body via ceramic insulation .The argon gas was admitted in to the source through a stainless steel pipe . Different thickness thin films of AL (600 A^0 , 800 A^0,1000 A^0) were prepared by thermal evaporation method of thin film deposition using a V-type filament . The thickness of the films was measured instantaneously with the deposition by an Automatic Deposition System connected to the vacuum system



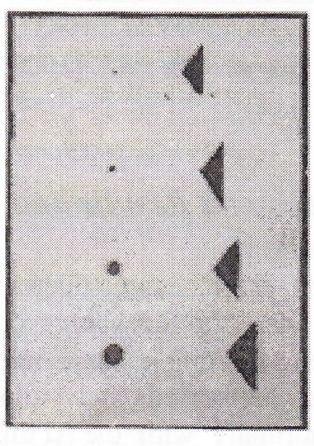
Figure(2): Schematic diagram of the ion source, deflector, vacuums chamber frame and the AL thin film target.

The films were placed in a solid frame having a slot of dimension (0.7cm x 4cm) in order to use the same film for several etching and to ensure having the same thickness . The films were placed at a distance of 3.5 cm from the source which was an ideal distance for which maximum axial ion to neutral ratio is obtained, Franks (personal communication) .

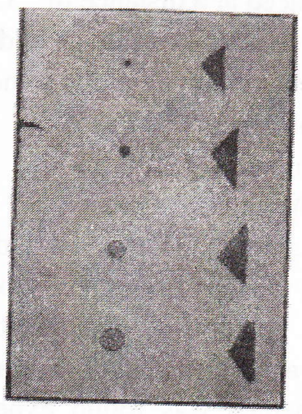
A nickel sheet of dimension (2cm.x1.5cm) was used as a deflector to separate the ions from the rest of the beam (neutral particles and electrons) and placed at a distance of 1 cm from the source which was found experimentally as a minimum distance for which no electrical break down occurs between the deflector and the earth 's source body .

For our source operating in the oscillating mode and within the pressure range (2 - 5) 10^{-5} Torr , it was calculated theoretically that the minimum ion energy is greater than 2 KeV, [13].

A 3 kV applied as the deflector voltage by which an observable and suitable spacing was obtained between the neutral and ion spots on the film targets as shown in the fig (3).



Figure(3): AL (600 A^0)



Figure(3): AL (800 A^0)

Figure(3): AL (1000 A^0)

3. Experimental Results and Discussion

From the schematic diagram of the apparatus and for the source operating within the oscillating mode an intense ion beam was performed and allowed to impinge normally with the Al thin films. Due to the deflector voltage (3 kV), two spots (sputtered areas) were observed on the films for each chamber pressure $\{(2\text{-}5)10^{-5}$ Torr$\}$.The circular one is due to the neutral particles which are not affected by the deflector and the triangular spot is due to the positive ions .The separation between the two spots depends on the ion's energy and the deflector voltage , Fig(3).

For a constant deflection voltage (3 kV) and different chamber pressure, different separations between neutral particles and ion spots on the Al target were observed which are due to the dependence of the Ions Energy on the chamber pressure. The only common phenomenon in all these experiments is the fact that, when deflecting the ions , they are not all deflected together by the same amount from the neutral beam to form a circular or elliptical spot on the target , which must be the case if the ions are all having the same energy. The deflected ions always form a triangle on the film target having one of its terminals near the neutral spot and the other two terminals are away from the neutral spot by almost the same amount.

The interpretation of this kind of deflection is that, the central portion of the ion beam is less deflected than the ions at the edges due to the different effectiveness of the deflection voltage on the ions of the beam, i.e. the ions in the central portion of the beam are little affected by the deflection voltage , while the other ions at the edges of the bean were more affected . This means that the ions in the beam produced by the a saddle field ion source have different energies and the ions in the central portion of the beam are more energetic than the other ions at the edges of the beam This fact also supported by [7] who states that the energy of the ions depends on the locations at which these ions originated within the ion source. Using another method [12] got the same conclusion and supports this work.

4. Conclusions

By using the above technique , one can observe visually that more energetic ions produced by a low pressure saddle field ion sources are those in the central portion of the beam and these ions decreases radially within the beam .

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ڕێگەیەکی بینراو بۆ زانینی شێوەی دابەش بوونی ووزەی ئایۆنی بەرهەم هێنراو بەهۆی سەرچاوەی ساردی ئایۆنەوە

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پوختە

لەم توێژینەوەیەدا ڕێگایەکی سادەی بینراو بەکارهێنرا بۆ زانینی بڕی ووزەی ئایۆنی بەرهەم هێنراو، بە هۆی جۆری خڕۆکەیی لە سەرچاوەی ساردی ئایۆن بە رهەم هێنەر، لە ئەنجامدا بۆمان دەرکەوت کە ووزەی ئایۆنەکە بەندە بە جێگەی ئلیۆنەکەوە لە گورزە گشتی‌یەکەدا، وە تا دوور بێت لە سەنتەری گورزەکەوە ئەوا ووزەکەی کەم دەبێت وە بە پێچەوانەوە.

طريقة مرئية لدراسة التوزيع القطري للايونات المنتجة بواسطة المصدر الايوني البارد حسب طاقتها

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الخلاصة

استخدمت طريقة مرئية لدراسة الايونات المنتجة بواسطة المصدر الايوني البارد من النوع الكروي و ذلك حسب طاقاتهم و مواقعهم القطرية داخل الحزمة الكلية. اظهرت الدراسة ان طاقة الايون تعتمد على بعدها عن مركز الحزمة، فكلما زاد بعد الايون عن المركز، قلت طاقته، و العكس صحيح.

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