AN ARC-DISCHARGE ION SOURCE

BAI GUI BIN

Institute of Low Energy Nuclear Physics Beijing Normal University

Abstract

This article introduces an arc-discharge ion source. The principle of it is the arc discharge combined with sputtering. As the structure, a discharging chamber of quartz, in which a quarth shroud, an annular anode, two cathode consisted of LaB_6 (or the metals) including one drawing electrode, an insulation flange plate etc. is used. It can produce gas ions and metal ions and multicharge ions. The ion current is 1ma to 14.5ma. The drawing structure are jointly shared by this source and the r.f ion source. Theis ion source have been used in a 40CkeV ion implanter at Beijing Normal University and it is stable in operation.

1. Preface

This ion source is made by synthesizing the characters of the r.f ion source[1][2] and the penning form ion source.[3] It has two structural forms, this paper has described the works in either case for comparison.

2. The characters and the principle of the ion source

The structure of the ion source has two forms, its is shown in fig.1 and fig.2. That shown in fig.2 is made is on the basis of the fig.1 and is improved. The comparison of the structure and the characteristics is recounted as follows.

Fig.1 showned the original structure of the ion source. 1-8 is an annular anode made of molybdenum, it is an ϕ30mm annular curved with ϕ2mm molybdenum wire. 1-7 is a cathode, and also works as an extracting electrode, in centre it has a round cavity with a diameter 2.5mm, long 8mm. 1-12 is anticathode. Two cathode are composed of the LaB_6. The potential between the extracting cathode and the anode is regulated by power 1-13: While the potential between the anode and the

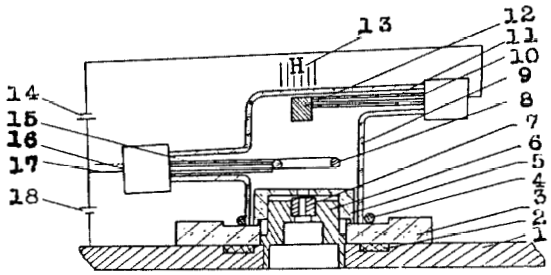

Fig.1 The original illustration of the ion source

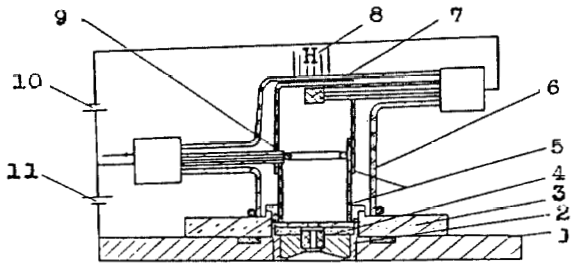

Fig.2 The illustration of the improved ion source

anticathode is regulated by power 1-14. 1-9 is discharge chamber made of quartz glass. 1-3 is the porcelain flange. 1-5 is shield cover made of quartz glass. Along the axis of the anode and two cathodes there is a magnet field (1-13), it is produced by an E form magnet. The magnetic line of force form reture circuit pass through the iron flange (1-1). The magnet field intensity is continuously adjustable over a range of 0-4000 gauss. When it is used, according to other parameters of the ion source the suitabe

CH2387-9/87/0000-0279 $1.00 © IEEE

PAC 1987

value is selected. The working material (gas) of the ion source imported into the discharge chamber from 1-16, where the quantity of the gas is controled by needle form valve. The extracting system is shared by this ion source and the r.f ion source. Two ion sources are alternately used in a 400keV ion implanter at Beijing normal university. The connection of the discharge chamber with the flange is sealed with rubber, and naturally cooling.

Fig.2 shows the structure after improvement. The purpose is to take larger power, increase the intensity of the extracting ion current, raise the proportion of the multi-charge ions in ion beam, and draw metal ions by adding sputtering. The difference between that shown in fig. 1 and fig.2 is: (1) A shield layer (Fig.2-5) made of quartz glass in added in the discharge chamber, it is kept apart with the inner wall of the discharge chamber. (2) The extracting electrode is moved by 25mm downward, makes the distance of two cathodes (2-4 and 2-7) be increased from 40mm in fig.1 to 65mm in fig.2. (3) Two cathodes can be changed into metals from which ions are to be extracted.

Two structures of the ion source have the same working principle. After the needed gas is introduced into the discharge chamber, according to potential distrobution shown in the figure, the voltage between the positive electrode and the negative electrode is added by power 1-18 and 1-14 or 2-11 and 2-10, then, the electrons move back and forth between the two cathodes and collide with the gas to make the gas ionized. The positive ions strike the two cathodes owing to electric field effect, many secondary electrons come out by being bombamded, thus much electrons participate in ionizing gas, and more positive ions are produced again. Along with this continuous process, the gas is ionized in the whole disharge chamber. When magnet field in axial direction charges from weak into strong, the electrons more reciprocally gradually restrainted in a range near by the axis which is composed of the centre of the two cathodes and the anode. As a result, the electrons flow density is increased, a ionized range which is a bright column is formed, and this plasma post can be condensed to a range of ϕ10mm to ϕ3mm by the magnet field. Under the action of electric field formed by the power 1-18 or 2-11, the ion beam can be abtained by extracting system.

Owing to this arc source and the r.f ion source are sharing a common extracting system, the extracting voltage (the anode to drawing electrode) and the arc voltage (the anode to the anticathode) is unequal in operating, and the extracting voltage is higher than the arc voltage, so as to keep good discharge condition and achieve optimum extracting effect.

3. The experimental result

3.1 The experimental result on the structure shown in fig.1.

(1) The experiment that takes varied gases as working material have been done for the arc source, such as, H, He, N, O, Ar, BF_3, PCl_3, BBr_3, and so on. Generally, intensity of the extracted ion current is 1ma to 3ma, but for Ar, the maximum is 7ma. In Fig.3, Fig.4 and Fig.5 the ion mass spectrum of BF_3, PCl_3 and Ar is shown respectively.

One can see from the graphs, besides single charge ion in ion beam extracted, same time there are muli-charge ion too. For example, the Ar^{++} occupies 25% of the Ar^{+} as shown in Fig.5.

(2) The gas consumption rate 18CC --- 180CC/hour, the source can be normally operated in this range, and its adaptability is strong to gas pressure.

(3) The power consumption, in usual case, is 150W to 200W.

(4) The lift time, after cleaning it can work continually (or accumulately) for 1 to 2 months.

(5) The emittance of the ion source is 2×10^{-6}cm rad, similer to that of the r.f ion source. This structure is used in a 400KeV ion implanter in Beijing normal university and it is atable in operation.

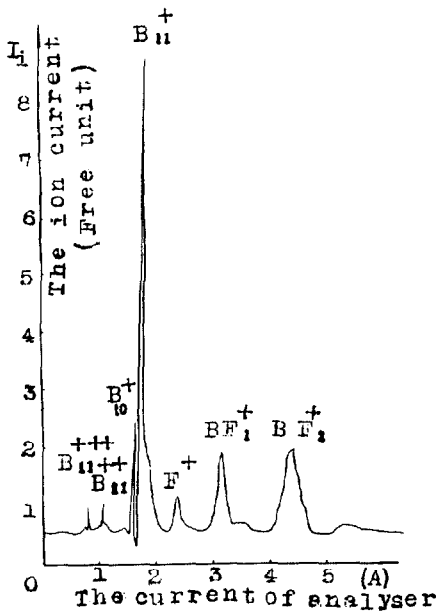

Fig.3 The ion mass spectrum of BF_3.

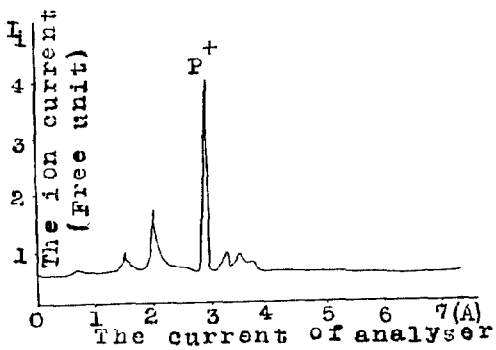

Fig.4 The ion spectrum of PCl_3.

3.2 The experimental result for the structure shown in Fig.2. Due to a shield cover made of quartz glass is added in the discharge chamber, the source can bear larger power, from original 150W or 200W increased to 1000W, yet by natural cooling, the rubber seal is still effective. The expected purpose is achieved with the experimental result. (1) When Ar is used as working material of the source, the ion current intensity is raised from original maximum 7ma to 14.5ma. (2) The proportion of the multi-charge ion raises in ion beam, from original 25% to 30%. (3) When two cathodes is replaced by the metal for producing desired ion, the metal ions shch as Mo^+, Ti^+, Fe^+, Y^+ etc, is extracted owing to the sputter technique is used. The ion mass spectrum of Y + CCl_4 is shown in Fig.6.

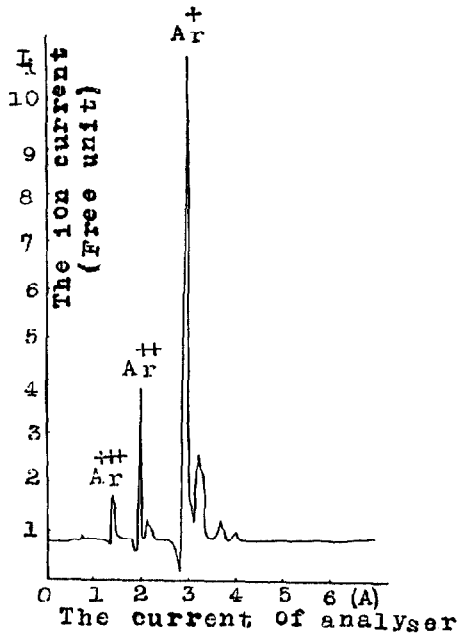

Fig.5 The ion mass spectrum of Ar.

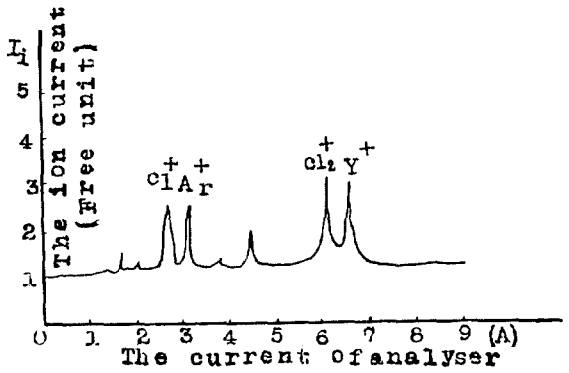

Fig.6 The ion mass spectrum of Y + CCl_4.

4. Concluding remarks

Compared with the r.f ion source, this ion source privides with a different discharge prinsiple, the oscillator is saved, therefore the disturbance of the r.f electromagnetic wave to the nearly electronic devices is eliminated. The multi - charge ions is produced. This structure makes the insulation problem of the high voltage simple and the short circuit can not occur. Owing

to the use of the quartz glass with small recombinetion factor as the discharge chamber and the shield cover and the use of porcelain flange, metals which are not to be exposed in discharge chamber are sheilded, the utilization ratio of the electrons and the ions is raised, the power consumption decrosed and the life time lengthened. The phenomenon in discharge chamber can directly perceived through the senses, when the electric field and the magnetic field is added, the oprating condition in the discharge chamber is clearly visibile. The theoretical design and the measurement can be directly compared with the experimental phenomenon, in favour of judging how the level of both sides in accord is. Another advantage this kind of source is to help for teaching in schools; students can observe phenomenon while listening to a lecture, grasping easily.

Refernce

(1) Ma mingxiu, Iao Wei, Bai guibin, Zhang tungxo, "An improved R.F. heavy ion source," Radition effects, Vol44 P207 (1979)

(2) Bai guibin, Weng weiguo, Ma mingxiu, Zhou feng sheng and Hao zhonghe, "The chemical synthesis and sputtering of working matarial in R.F. heavy ion source," Joarnal of natural science of Beijing normal university, No4 (1982) 29

(3) R.C. Meyerand, S.C.Brown," High- current ion source", Rew. Scient. Instrum. (1959) 30, 110.