PA07

Study of ECRIS for highly charged ion production - HiECR MK3 -

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1. Introduction

The former HiECR had good performances in 6 and 10 [GHz] operations, while in the case of 14 [GHz] operation, the intensity of highly-charged heavy ions was very low [1,2,3]. It seemed that the result was due to the narrow gap(3[mm] or less) between the surface of ECR zone and that of the chamber wall.

HiECR MK3 has been designed to produce strong axial mirror field and radial hexapolar field enough to 14 [GHz] operation.

The HiECR MK3 was constructed and operated for the first time.

2. HiECR MK-3

The former HiECR had been operated with the microwave frequency 6 or 10 [GHz]. Therefore some improvements were required so that the MK3 can be operated at 14 [GHz]. The number of mirror coils has added up to 9 (MK2: 7), the plasma chamber has been modified and the hexapole has been made newly. Schematic view of HiECR MK3 is drawn in Fig.1 and main parameters are shown in Table.1.

Table 1
Main parameters of HiECR (MK-3) Ion Sources

Microwave frequency	14	[GHz]
Diameter of chamber	70	[mm]
Hexapole magnet		
hexapole field on surf.	13.1	[kG]
material	Nd-Fe-B	
inner diameter	76	[mm]
length	145	[mm]
Mirror coils		
no. of coils	9	
max. current	600	[A]
max. power	57	[kW]

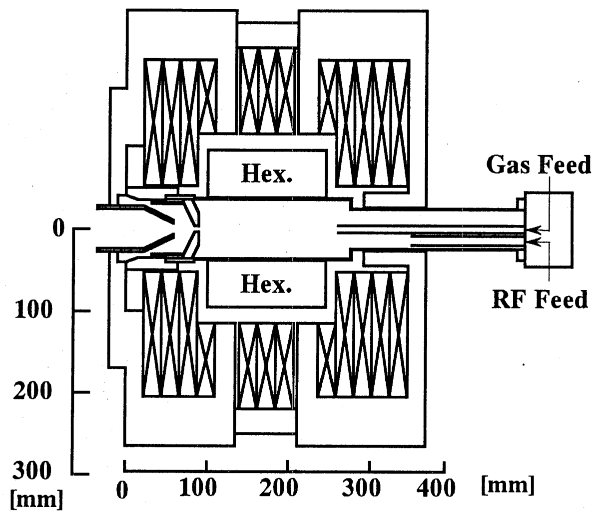

Fig.1. Schema of HiECR MK-3

3. Magnetic Field

radial hexapoler field

Radial hexapoler fields were measured along the axis and radius(Fig.2). The value is 13.1[kG] at the chamber surface.

axial mirror field

We measured the axial mirror field through the axis(r=0) with mirror coils current 600[A]. The result is shown in Fig.3.

ECR zone

The magnetic field components $\left(B_r, B_\theta, B_z\right)$ at a position $\left(r, \theta, z\right)$ in the cylindrical coordinates is the following.

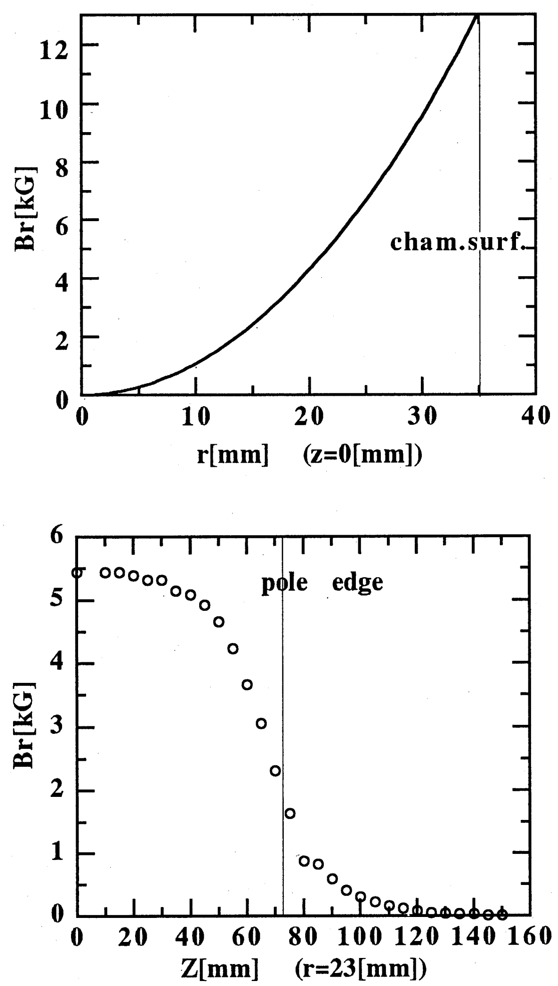

Fig.2. Radial hexapoler field

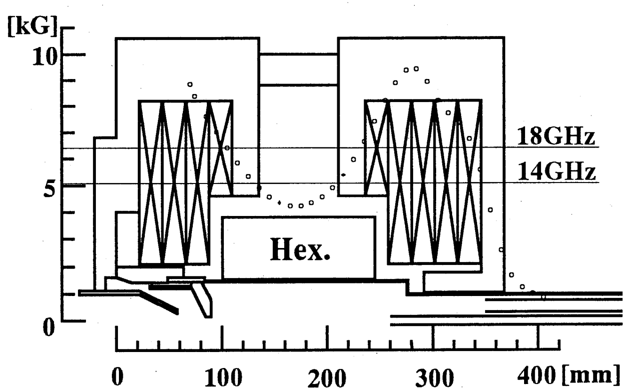

Fig.3. axial mirror field distribution(mirror coils current 600 [A])

$$B_r = B_r^{sol} + B_r^{hex}$$

$$B_\theta = B_\theta^{hex}$$

$$B_z = B_z^{sol} + B_z^{hex}$$

$$|B| = \sqrt{B_r^2 + B_\theta^2 + B_z^2}$$

The closed surface $|B| = m_e \, \omega_{rf} / e$ is called ECR zone and electrons are accelerated in this surface.

From the radial and axial field measurements, the axial size of the ECR zone is 78[mm] long and the diameter is 36[mm](the gap between the surface of ECR zone and that of the chamber wall;17[mm]).

3. First operation

Fig.4 shows a Ne ions spectrum obtained at the first 14 [GHz] operation. Wide peaks exists on right sides of every charge-state peaks. These seemed to be produced by the ions which had captured an electron in acceleration gap(Fig.5). The vacuum must be improved after this.

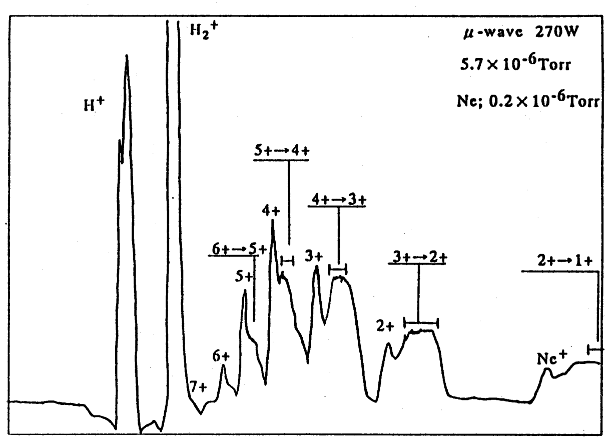

Fig.4. ^{20}Ne ions spectrum

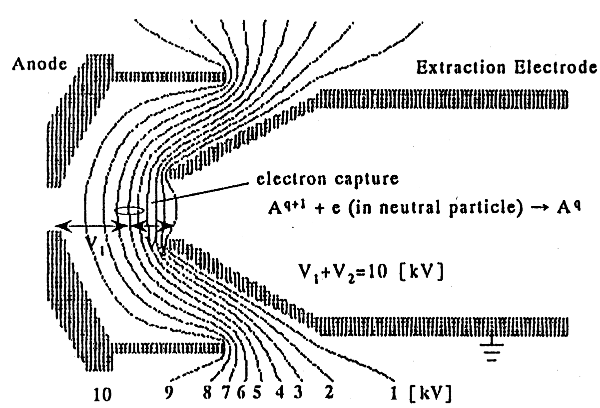

Fig.5. one electron capture in acceleration gap

4. Plasma volume and shape effect

In general, $+q$ charged ions current extracted from a plasma with volume V is following [4].

$$I \approx \frac{n_q qeV}{\tau_q}$$

As concerns ECRIS, this relation is more complex because of influences of the anode position and the anode hole size and so on.

The new hexapole does not have return-yokes and it is covered with SUS and the surroundings of SUS are insulated by ethylene chloride.

Solenoid coils for adjustment of plasma volume are been possible to set around the new hexapole because of nothing of return-yoke. By varying the diameter of ECR zone, we will investigate the best plasma shape to generate highly-charged ions.

References

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