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DEVELOPMENT OF THE HIECR ION SOURCE (2) -14GHz-

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ABSTRACT

We have remodeled the HIECR, which has been operated at 6GHz, into the x-HIECR operating at 10GHz and 14GHz. Charge spectra of neon ions were measured for 10GHz operations and an enhancement of the yields in higher charge state was observed. For 14GHz, this is under improvement, and yet we will report the present circumstances.

INTRODUCTION

The performance of HIECR ion source for 6GHz operation was studied from 1988 to 1990 [1-3]. Since 1990, we are studing the performance of the remodeled HIECR, x-HIECR. This remodeling was designed in order to investigate dependency of the performance on operating frequencies. In practice, we remodeled two parts of the source. One is the solenoid coils. The axial magnetic field strength was increased from 8.5kGauss to 9.4kGauss by adding coils. The other is the RF injection method. That was remodeled for easy installation of a wave guide and a RF window.

This study has made in cooperation with the Institute for Nuclear Study, the National Institute of Radiological Sciences and The Japan Steel Works LTD.

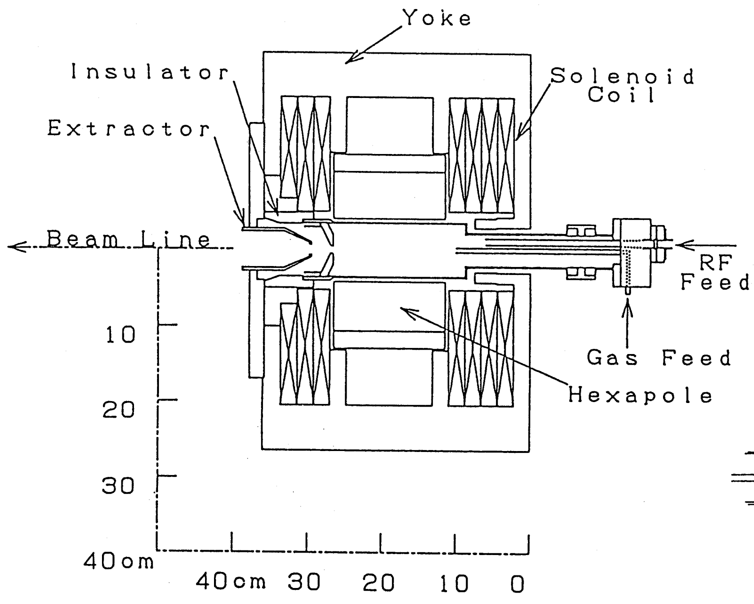


fig.1 The schematic drawing of the x-HIECR

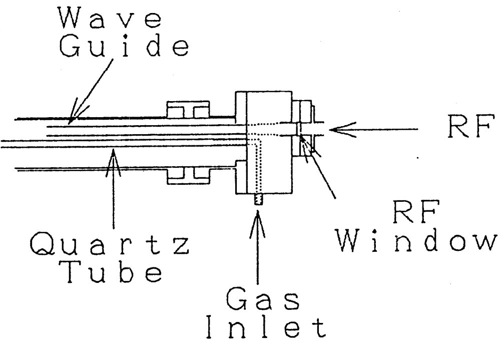
Size	
Length	358 mm
Width	530 mm
Chamber Diameter	70 mm
Microwave Power Source	
Frequency	14.0 GHz
Mirror Coil	
No. of Coils	7
Max. Current	600 A
Max. Field on Axis	9.4 kGauss
Multipole Magnet	
Multipolarity	Hexapole
Inner Diameter	84 mm
Length	150 mm
Material	Nd-Fe-B
Field Strength on Surface	6.4 kGauss
Vacuum Pump	
1500 l/s TMP × 1	

table 1 Main parameters of the x-HIECR

DESIGN AND STRUCTURE

Fig.1 shows the schematic drawing of the x-HIECR ion source. The axial magnetic field is produced by solenoid coils with seven pancakes. They are divided into two groups. Each group can be independently excited to optimize the axial field distribution. The radial field is produced by a set of Nd-Fe-B hexapole magnet. A hexapole field strength of 5.8kGauss was obtained on the inner wall of the plasma chamber. The magnet system mentioned above produces a minimum-B structure.

Microwave is fed into the plasma radially and directly in order to minimize



power losses on the way from the RF amplifier to the plasma. A RF window is made of Al_2O_3 ceramic. A gas feed line is made of a quartz tube with a inner diameterof 6mm. A 1500l/s turbo-molecular pump is installed between ECRIS and the analyzing magnet.

Table 1 shows main parameters of the x-HIECR.

TEST STAND

The source is installed at a test bench and the extracted ions with an extraction voltage of 10kV are analyzed by a 45deg bending magnet with circular pole pieces of a diameter of 20cm and a pole gap of 5cm.

After extracted from the extraction hole with 13mm diameter, ions are focused to an entrance slit by an einzel lens. And the ions are analyzed to a Faraday cup behind a image slit. A 500l/s turbo-molecular pump is installed between the analyzing magnet and the Faraday cup.

EXPERIMENTS AND RESULTS

After the installation at the test bench, the performance of x-HIECR was investigated.

Fig.2 shows a typical charge state spectrum of neon obtained with RF frequency of 10GHz. Analyzed ion currents as a function of a magnetic field strength on the analyzing magnet are presented. In this case, the source has been tuned for Ne^{6+} ions; RF power = 150W, extraction voltage = 10kV, drain current = 1.7mA, and vacuum pressure just behind the extractor = 7.2×10^{-7}torr. Obviously there is a peak at 4+ charge state. Though it is a little difficult to know from this figure, argon ions up to 8+ charge state are observed.

Fig.3 shows a spectrum of neon ions obtained with 14GHz. The spectrum distributes in low charge state compared with the result of the 10GHz operation. The field strength of the hexapole permanent magnet is 5.8kGauss on the inner wall of the plasma chamber. Therefore the result shown in fig.3 can seem to be attributed to the insufficient radial magnetic field. It seems that the extraction efficiency of ions from a quadrupole field is lower than that from a hexapole field. Neverthless, we tried once againwith a quadrupole in hand, the field strength of which is 6.8kGauss and stronger than the hexapole, because we expected to get a spectrum distributing in higher charge state. Table 2 shows main parameters of the quadrupole. The result, however, was not satisfactory; The edge of the quartz tube was coated with metal material, which seemed to be iron sputtered from the extractor made of iron. This deposition of metal layer makes the ignition of the plasma imposible. We are now in process of overcoming this problem.

Multipole Magnet	
Multipolarity	Quadrupole
Inner Diameter	84 mm
Length	150 mm
Material	Nd-Fe-B
Field Strength on Surface	7.6 kGauss

table 2 Main parameters of the quadrupole

SUMMARY

The sputtering of the extraction electrode is a serious problem under 14GHz operations. The material of the extraction electrode, however, has to be iron in order to increase a axial field. So we must solve the problem soon. And also from a viewpoint of beam optics, we must optimize the configulation of the extractor and the anode to raise the extraction efficiency. We would like to investigate dependency of the performance on operating frequencies in the near future by all means.

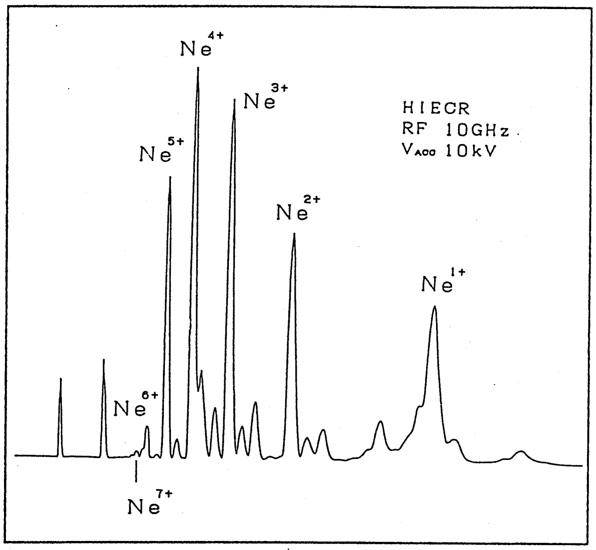


fig.2 a spectrum of Ne obtained with 10GHz operation. Analyzed ion currents as a function of a field strength on the analyzing magnet are presented.

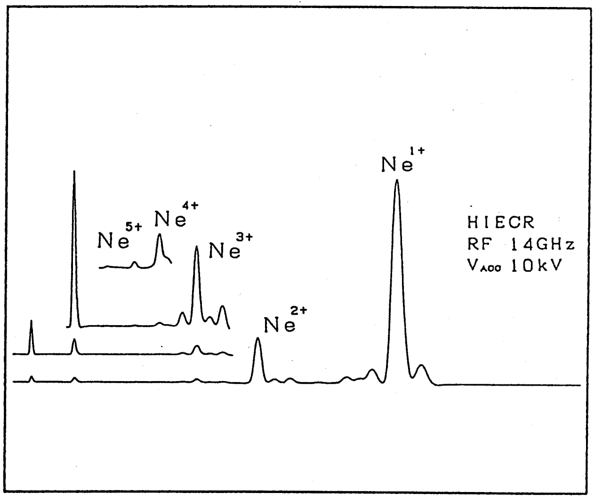


fig.3 a spectrum of Ne obtained with 14GHz operation

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