COMMISSIONING OF IMP 14.5GHZ ECR ION SOURCE

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A 14.5 GHz new ECR ion source has been designed and constructed for the upgraded injection beam line of HIRFL SFC(Heavy Ion Research Facility in Lanzhou, Sector Focus Cyclotron) so that eventually two ECR ion sources could be available on the line. The new ECR ion source has a compact structure with a high magnetic mirror ratio and a long chamber. The maximum axial magnetic field on the axis is around 1.5Tesla and the hexapole field on the chamber wall is 1.0Tesla. The ion source is being tested on the test bench. The preliminary results are typically 100 eμA of O^{7+}, 160 eμA of Ar^{11+} and 50 eμA of Xe^{26+}. The design points, characteristics and commissioning are presented.

1 Introduction

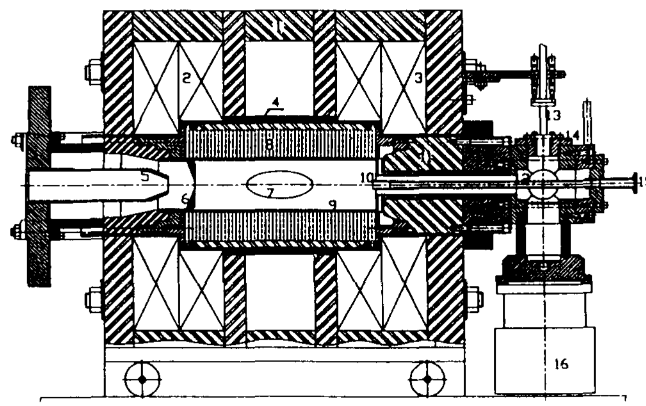
The axial injection beam line of Heavy Ion Research Facility in Lanzhou (HIRFL) was upgraded in 1997 in order to improve beam intensity and operation efficiency[1]. A new ECR ion source with RF frequency 14.5GHz was constructed to satisfy requirements of the new injection beam line. The design goal of this new ECR ion source is to produce intense ion beam with sufficiently high charge state particularly for heavy elements. Metallic ion beams are also one of main tasks for the new ECR ion source.

In recent years, several groups have reported that using high axial and radial magnetic field could improve performance of ECR ion source for high charge state[2-8]. Therefore, increasing both axial and radial magnetic field was the main design point of our new ECR ion source. Another point was to increase the plasma volume which is believed to be beneficial to the production of high charge state ions. So a plasma chamber with large volume was designed. It is clear that high microwave frequency with a good design of magnetic field configuration could increase beam intensity of high charge state ions[9]. We decided to adopt 14.5GHz RF frequency for our new ECR ion source since we already have two ECR sources in operation with 10GHz[10-11].

This new ECR ion source is on our test bench for commissioning. In the end of 1998 it will be put into operation for our cyclotron. In this paper, we present the description of our new ECR ion source, commissioning and preliminary results.

2 Description of the IMP 14.5 GHz ECRIS

Figure 1 illustrates the main structure of the IMP 14.5 GHz ECR ion source. While the overall structure still follows CAPRICE source[2] and ECR4[12], there are some significant differences on the magnetic field configuration and dimensions of the plasma chamber. The design of the magnetic field configuration takes into account the latest understanding that high axial and radial magnetic field, long resonance length and reasonable magnetic field gradient are important for improving the performance of high charge state ions. As shown in Fig.1, the axial magnetic field is produced by two solenoids and surrounding ion yoke. Each solenoid consists of 6 double layer pancakes with two types of internal diameter. The typical current of the coils is around 1000 A. The total power consumption of the two solenoids is about 80 kW which is provided by two separated power supplies. The maximum axial peak magnetic field on the axis is 1.5Tesla, which is shown in Fig.2. The hexapole consists of 24 pieces of trapezoidal NdFeB magnet which is mounted into an iron cylinder. The hexapole field on the plasma chamber wall can reach 1.0Tesla. The plasma chamber is made of stainless steel, which has a double wall that cooling water is running inside. The internal diameter of the plasma chamber is 70 mm and the length is 300 mm. The RF power is fed into the ion source through the coaxial line. The RF generator was manufactured in China with THOMSON klystron (14.5GHz, 2.5kW). Another configuration of the ion source was also designed and fabricated in which RF power is launched into the ion



1. Ion yoke 2. Extraction solenoid. 3. Injection solenoid 4. Insulator 5. Puller 6. Plasma electrode 7. Plasma 8. Hexapole 9. Chamber 10. Quartz tube 11. Conical iron ring 12. Coaxial line 13. Wave-guide 14. Microwave window 15. Gas feed 16. Molecular pump.

Figure 1 : Schematic view of IMP 14.5GHz ECRIS.

source through rectangular wave guide so that it could be convenient to metallic ion production and double frequency heating[7].

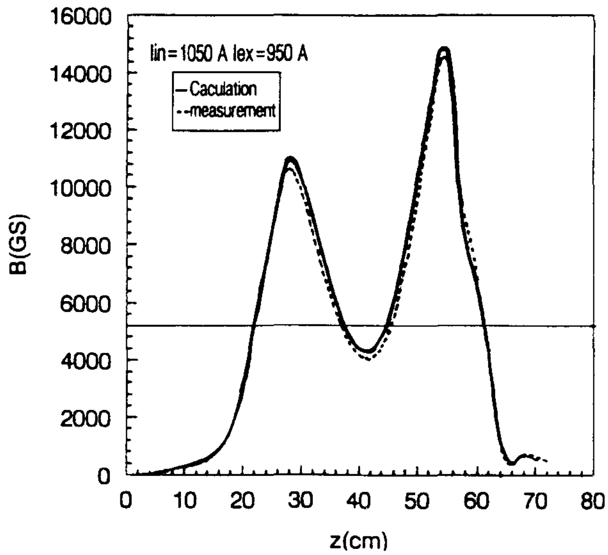


Figure 2 : The axial magnetic field distribution on the axis.

3 Commissioning and Results

Commissioning of the IMP 14.5 GHz ECRIS began from September of 1997 after completion of its mechanical assembly. During test of the ion source, the primary optimization was focused on those high charge state ions such as O^{7+}, Ar^{11+} and Xe^{26+}, which are important for our cyclotron. The coaxial line was DC biased when the source was tested .

In the early tests, the RF power can only be raised up to 300 W because of discharge between the puller and the iron ring at the extraction side which caused the ion source unstable and resulted in very large load current of the high voltage power supply , in that case, 70 eμA of O^{7+} could be obtained. This problem was solved by putting a ceramic tube around the puller. After that, 100 eμA of O^{7+} could be got at 600-800 W RF power. There was no gas mixing effect when we used Helium as support gas.

In order to improve beam intensity, an aluminum tube was inserted into the plasma chamber[11][13]. It increased the Ar^{11+}beam intensity from 130 eμA to 160 eμA with RF power 600-800 W, in which the plasma electrode had to be put deeply into the chamber. With the aluminum tube, the position of the plasma electrode was sensitive and the gas consumption was decreased obviously. The typical vacuum measured at the extraction side was around 4×10^{-7}mbar when the source was running. Sometime the beam was not very stable that might be because the aluminum tube was over heated and the surface condition had been changed. At this moment, when we decreased RF power about 100 W and waited for a few seconds, and then raised RF power again, the beam could come back and remained stable. There was also no gas mixing effect when we injected Oxygen or Helium into the source. But it is really effective to keep the source running with Oxygen for two or three hours before testing Ar^{11+}. Fig.3 indicates the spectrum optimized on Ar^{11+}. The ion source was also tested with Xenon-129 after running Argon. To a little bit surprise, the Xenon beam was much more stable than the Argon beam, and it was not difficult to get 50 eμA of Xe^{26+}. The gas mixing effect with Oxygen as support gas was obvious. The spectrum to optimize $Xe^{26+}$is shown on Fig.4 from which a little bit Argon could also be seen.

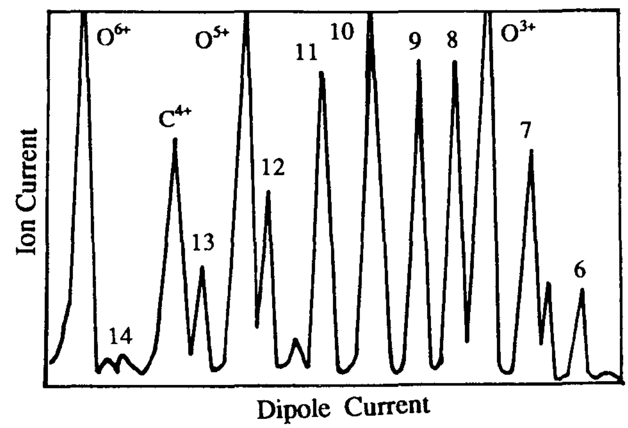


Figure 3 : Argon spectrum to optimize Ar^{11+}.

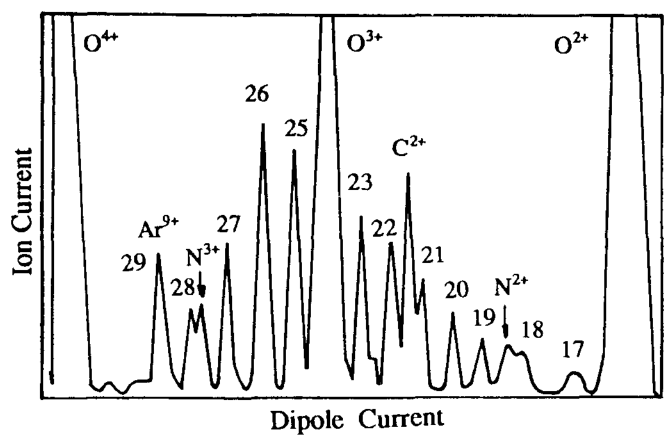


Figure 4 : Xenon-129 spectrum to optimize Xe^{26+}.

After three months commissioning, the typical ion beam currents we could obtain from our new ECR ion source are listed in Table 1. The transmission efficiency of our test bench was estimated only about 50%. The ion beams in Table 1 were extracted at voltage of 15 to 18 kV through an 9 mm aperture of the plasma electrode. The beam defining slit was opened from 6x6 to 20×20 mm. Beam currents were measured by a Faraday cup biased at 100 V to suppress the secondary electrons. The 99% enriched Xenon-129 isotope and natural krypton were used during the tests.

Table 1 : Test Results of the 14.5 GHz IMP ECRIS

Ion	Currents(eμA)
O^{6+}	560
O^{7+}	100
Ar^{8+}	460
Ar^{11+}	160
Ar^{12+}	80
Ar^{13+}	23
Kr^{18+}	60
Kr^{19+}	50
Kr^{20+}	25
Xe^{26+}	50
Xe^{27+}	25
Xe^{28+}	12

4 Conclusion

A 14.5 GHz new ECR ion source was constructed and tested successfully. The commissioning results for high charge state ions are satisfactory and encouraging, which further demonstrates that high magnetic field and large plasma volume could improve the performance of an ECR ion source for the production of high charge state ions. The second configuration of this ion source, metallic ion production and double frequency heating will be tested in the next few months.

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