Lanzhou All Permanent ECR Ion Source No.1 —LAPECR1*

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Abstract The Lanzhou All Permanent magnet ECR ion source NO.1 (LAPECR1) is the first all permanent magnet multiple ECRIS made in IMP. This ECRIS is running at 14.5GHz and can provide intense low charge state ion beams (varying from several to hundreds of eμA) or medium charge state ion beams (varying from several to tens of eμA). The size of source body is Ø102mm×296mm, the compactness and economical features enable the source suitable to be put on a HV platform or equipped by a small laboratory. This article gives the main parameters of the ion source.

Key words all permanent magnet, HV platform, major parameters

1 Introduction

Electron Cyclotron Resonance (ECR) ion source[1] can be divided into many kinds by the way that the magnetic body produces the 3-D magnetic confinement field, such as solenoidal coils kind ion source, superconducting ion source, all permanent magnet ion source, and so on. Each of them has the characteristic of itself. The all permanent magnet ion source has the virtues like compactness, easy-handling, long-time operation stability, cost-saving, low running expense, large power electricity free and high pressure water-cooling free etc[2, 3]. These features enable its possible industrial applications such as ion implantation.

LAPECR1 (the Lanzhou All Permanent ECR ion source NO.1) is the first all permanent magnet ECRIS made in IMP. The designing, fabrication and operating of this ion source provides us a lot of experience about the all permanent magnet ECR ion source. This article gives the major parameters of the ion source and the results of the first plasma.

2 Source design

The main magnetic field parameters of the source are given in Table 1. The axial magnetic field is produced by two permanent magnet rings and the radial magnetic field is provided by one haxepole. The photo of the hexapole magnet is shown in Fig. 1.

Table 1. the magnet distribution of LAPECR1.

B_{inj}	0.62T (1.0T)
B_{ext}	0.56T
hexapole surface	1.1T
L_{mirror}	74mm
L_{ECR}	55mm
plasma chamber ID	45mm

The axial magnetic mirror peaks are B_{inj}=0.62T and B_{ext}=0.56T. The axial magnetic field distribution along the symmetrical axis is given in Fig. 2. The magnet body is all made from N45M NdFeB magnet

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segments, because the material has higher temperature coefficient, and larger remanence and $(BH)_{\max}$.

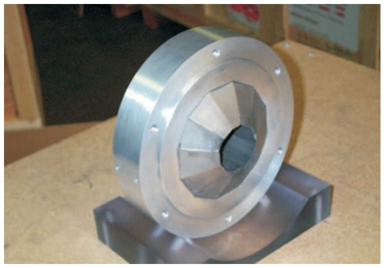

Fig. 1. The Photo of the hexopole.

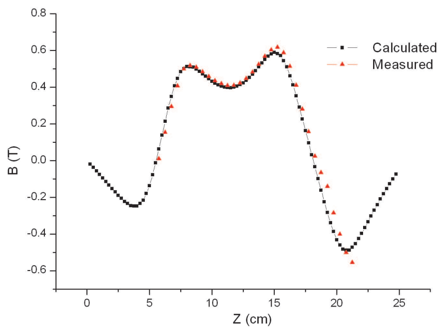

Fig. 2. The measured and calculated axile magnetic field.

One prominent merit of this all permanent magnet ion source is the structure simpleness. The injection side of the source is only composed of a microwave power injecting system, one gas input system and a biased-disc electric power feed-through (as shown in Fig. 3). At the extraction side, we use the simple two-electrode extraction system. Simple design of the source structure makes the source maintenance and operation easier. The de-ionized water-cooling system ($1\mathrm{kg/cm^2}$) is used to cool down the ion source. For the magnet body is all permanent, the ion source is very compact: the size of the source body is Ø102mm×296mm, and the weight is 25kg. Since the source is a large electricity power free and high pressure cooling water free equipment, it is very suitable to be put on a HV platform or equipped to a small laboratory for the purpose of many experiments with heavy ion beam requirements. For example, the LAPECR2 has been put on the 320kV HV platform at IMP[4], and thus the facility can deliver intense high charge state heavy ion beams with the energy range of 10keV/q $\sim$ 320keV/q to satisfy various experimental research requirements.

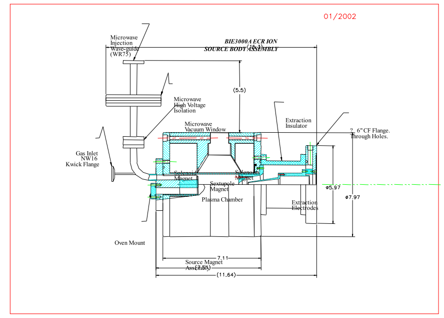

Fig. 3. The structure of ion source.

3 Result of the operation

LAPECR1 is designed to run at 14.5GHz with the extraction HV 10—40kV, and provide intense low charge state ion beams (varying from tens of eμA to hundreds of eμA), such as He^+, He^{2+}, B^+, C^+, C^{2+}, O^+, O^{2+}, N^+, N^{2+}, Ar^+ or medium charge state ion beams (varying from several eμA to several tens of eμA), such as B^{4+}, C^{4+}, N^{3+}, O^{6+}, Ne^{8+}, Ar^{8+}.

The ion source had been ignited in September, 2006. Fig. 4 presents the plots of the test bench for LAPECR1. The vase vacuum condition can reach up to 2×10^{-7}mbar at the source extraction region. With 100W 14.5GHz microwave feeding, we obtained 2.5mA stable mixed multi-charged ion beams at the extraction side of ion source when 10kV biased extraction HV was applied. The input working gas is O_2. Since the analyzer magnet power supply is under repairing, the analyzing of the mixed ion beam is scheduled.

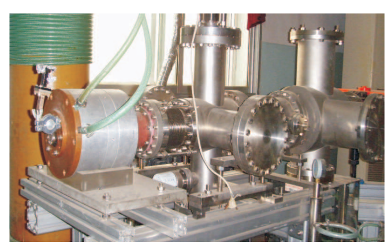

Fig. 4. The source and the transmit line.

4 Future plans

The ion source is in the commissioning period, so the beam line including one three-column electric lens and one analyzing magnet is not working well. In order to improve the source, a lot of work needs to be done. For example: improving the axial magnetic field distribution, floating the source and also the whole ion beam transmitting line from the ground to obtain ion beams of broader energy range (from several tens of eV/q to 20keV/q), improving the three-column electrostatic lens or put a Glaser lens at the extraction side to help optimize the ion beam extraction and transmission. Fig. 5 gives the ion beam tranmission simuletion result for LAPECR1 beam

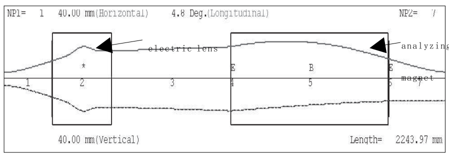

Fig. 5. The beams simulated by TRACE-3D.

line. When the source test is accomplished, many scheduled experiments will be done on the beam line. One of the experiments is to study the transmission behavior of low energy multi-charged ion beams between the ECR ion source and the analyzing magnet. Emittance study of multiple charge state ion beams is also another interesting direction.

5 Conclusion

This all permanent magnet ion source is just in the preliminary commission period. During the operating time, we find that the more improving done with it, the better is the performance of the ion source. So it some source conditioning time is needed to obtain good performance. Intense mixed ion beams has been extracted with only 100W rf power feeding. Intense analyzed multiple charge ion beams like He^{2+},C^{4+}, O^{6+}, Ar^{8+} are scheduled to be obtained in the next tuning period.

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