Fig. 3 External conductor before polishing.

Fig. 4 External conductor after first time polishing.

Fig. 5 Internal conductor after first time polishing.

Fig. 6 Internal conductor after second time polishing.

More abradant was added for the second time polishing, the central line was over the central line and rotation rate was increased. After 96 h, the treatment for internal conductor showed remarkable effect. Sputtering barely existed near weld joint and cannot be removed thoroughly at weld joint due to larger particles.

Weighing calculation and averaging ultrasonic measured results of selected points were used as two ways to calculate thickness. The results of weighed thickness are shown in Table 2. It indicates that more abradant addition and higher rotation rates will lead to more efficiency of roll polishing.

Table 2 The removed amount of polishing

	Total amount (g)	Calculated thickness (μm)	Removed thickness per hour (μm)
First time	54	8	0.08
Second time	119	23.6	0.25

When the cavity surface was measured, a straight line was selected at same place. 22 points were selected averagely on the line and thickness of each point measured by ultrasonic. After the trend graph was obtained, average curve was got by fitting process. It should be noted that these graphs only reflect the overall variation tendency of thickness due to more curved surface of cavity and greater measured errors.

6 - 16 Summary of Ion Source Group Work in 2012

Sun Liangting

2012 is a very busy year. With the progress of many projects and scientific activitiesat IMP, more efforts from the ion source group are needed. The following contents are going to summarize the main contributions and achievements from the ion source group, which also leads to the scope of the activities in the ion source group for year 2013.

In addition to the two existing ion beam injectors SECRAL and LECR3, a third injector ion source LAPECR1 was installed and put into operation for HIRFL in 2012. This was made by the modification of the layout of the old injection line. The LECR3 ion source injection line was lengthened and a 90 degree bending magnet was inserted which was used to bend the ion beam from LAPECR1 ion source 90 and then merge to the LECR3 injection line. LAPECR1 source was floated on a compact HV platform that could be biased to 36 kV which enables the injection of intense light ion beams such as H^+ or H_2^+ with the energy more than 25 keV/q. The total operation time of the ion sources for HIRFL is more than 7200 h in 2012, which is the sum of about 3000 h from LECR3, more than 3890 h from SECRAL and some beam time from LAPECR1. Totally 18 types of ion beams have been successfully delivered for kinds of experiments. High charge state tin ion beam was first time accelerated with HIRFL accelerators. For this operation, $^{112}Sn^{26+}$ was chosen as the principle ion which was delivered by SECRAL (Fig. 1 gives the typical spectrum during the operation). The average operation beam intensity was around 50 eμA. After about 2 months' continuous operation, the average material consumption rate was found to be around 1.4 mg/h. The machine time of the 320 kV HV platform was over 6000 h in 2012 which included about 5000 h for the experiments at the 5 successive terminals and 1000 h for new beam tests and source conditioning. 73 different species of ion beams have been delivered.

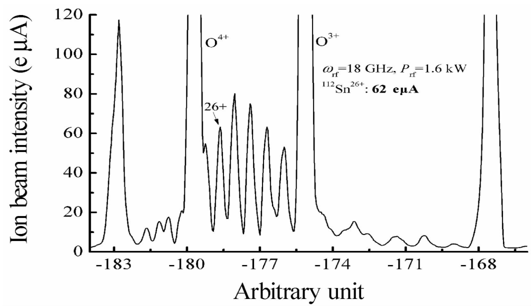

Fig. 1 Typical spectrum for $^{112}Sn^{26+}$ beam production with SECRAL.

Fig. 2 Prototyped mirror solenoid magnet for LECR4 ion source.

Major change was made to the LECR4 (or the DRAGON) ion source design. Since the former design that could house a large diameter plasma chamber needed huge electricity power and the large bore hexapole magnet might not be completed within the project time schedule, the main parameters of LECR4 are scaled down to those applied with LECR3 ion source. The prototyped pancake coils that are cooled with the evaporation technique (as shown in Fig. 2) was successfully tested, which demonstrated the temperature requirements and field configuration. The ion source mirror field coils and housing hardware are under fabrication and the axillary stuff of the ion source has also been sent to external vendor for fabrication. The source assembly and commissioning is scheduled in 2013. The intense proton ion source for the Compact Pulsed Hadron Source or CPHS project in Tsinghua University was successfully delivered to the user with more than 65 emA proton beam delivered to the RFQ entrance at the source extraction potential of 50 kV. Major change has been made to the source ion beam extraction system to enable long term operation stability and reliability. Fig. 3 gives the chart of long term operation status monitoring for about 150 h. For the Chinese ADS project, CW beam with the intensity of more than 15 emA and energy of 35 keV is required. The prototype ion source has been successfully tested and the dedicated ion source together with a newly designed LEBT has been sent to manufacture, which will be ready in the early 2013. The negative hydrogen ion source for the Positron Emission Tomography or PET project made promising progress in 2012. More than 1 emA H^- ion beam was detected at the downstream faraday cup. A 40 h continuous test with the ion source was also successfully performed which demonstrated the machine's operation reliability. Future work on this project is to improve the beam intensity and to do a systematic beam quality study. LAPECR3 ion source is an all permanent magnet ECR ion source built for the Heavy Ion Medical Machine or HIMM (formerly called HITFiL) project at IMP. Major progress was made in 2012 on this project. The ion source was put on a test bench (Fig. 4) and intense carbon beams were extracted. 100 eμA C^{5+} was detected on the faraday cup after beam analyzing, which is well up to the project beam intensity needs. The next step work will be focusing on beam quality analysis and optimization. As for laser ion source or LIS development, besides carbon ion beams, heavier beams such as lead ion and aluminum ion were produced with the source that employed a 3 J 1064 nm YAG laser machine. Very high charge state aluminum ion beams were detected but as for the case of lead beams, only several low charge state peaks were shown in the spectrum. More experiments in 2013 will help to understand this phenomenon. To promote the research on more powerful LIS source, a dedicated laboratory was refurbished in 2012. The new lab is equipped with a very spacy clean room (Fig. 5) that enables the efficient transmission of high power density laser and a good protection to the optical system. The experimental setups will be put in position in 2013.

HIRFL facility needs a second high performance ECR ion source, and especially a backup machine for the existing SECRAL ion source, and therefore SECRAL II project was launched in 2012. SECRAL II is almost a duplicated ion source of SECRAL, except for the cryogenic system. SECRAL II source will incorporate the techniques that have been successfully used in the fabrication of SECRAL cold mass. Major change will be made to the cryogenic system design, since SECRAL II cold mass will be cooled by the liquid helium circulated through cryocoolerrecondensing. Fig. 6 is the mechanical drawing of the SECRAL magnet system which has employed 5 GM type cryocoolers. Some efforts of R & D for next generation ECR ion source was made in 2012. For the moment, the discussion on the most feasible magnet structure didn't come to a conclusion yet. VENUS type, SECRAL type and MK-I type, each of them has the specific merits and problems. Anyway, more effort will bemade for this investigation in 2013. We also have a team working on a new concept intense proton beam ion source. This proton ion source will be heated with 14.5 GHz microwave power, and thus the structure, especially the microwave coupling system is much different from the traditional 2.45 GHz source. The source magnet body was ready and soon will be put on a test bench. The commissioning will soon be made.

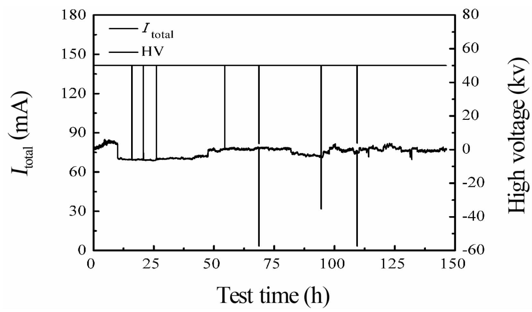

Fig. 3 CPHS proton ion source 150 h long term stability and reliability test chart.

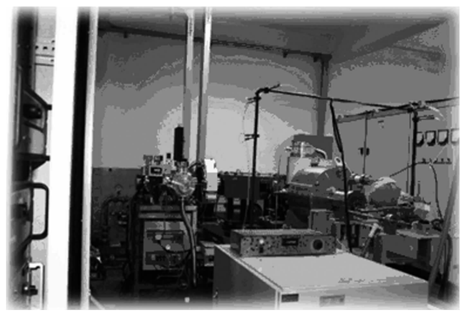

Fig. 4 The picture of LAPECR3 ion source and the test bench.

Fig. 5 The picture of the clean room for a new LIS laboratory at IMP.

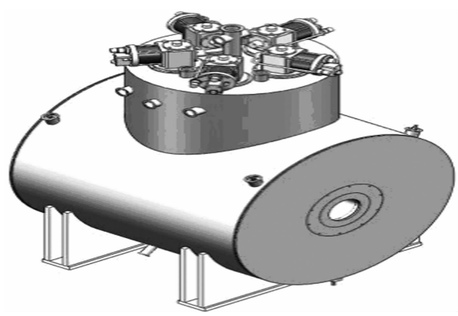

Fig. 6 The mechanic drawing of the SECRAL II ion source magnet.