§8. Study on Optimization of Gas Species and Thickness to Generate Au^+ Ion Beam with Tandem Accelerator for LHD-HIBP System

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In order to improve the heavy ion beam probe on LHD (LHD-HIBP), it is important to increase current of a probing beam. One of a method of increasing the current is improvement of charge exchange efficiency at a gas cell in the tandem accelerator for LHD-HIBP [1]. The objective of this study is to research physics of atomic collision between Au^- ion and atoms in a gas cell at the high voltage terminal with experimental and theoretical approaches.

It is difficult to conduct of experiment for charge exchange experiment in variations of gas spices and gas pressure in a gas cell of LHD-HIBP [2]. So, a theoretical model for charge fraction in a gas cell is constructed, then the verification is carried out at the tandem accelerator of Kobe University in which to change gas species, gas pressure, and beam energy can be easy. This machine is made for analyzing a sample with Rutherford-Backscattering Spectroscopy (RBS) method etc., and low *Z* ion (less than 6) is typically accelerated. As the accelerator system is installed for such light ions, there is a limitation for beam energy for our experiments. Au^+ is too heavy to be bent toward the detection chamber at a bending magnet.. Therefore, the terminal voltage is limited to about 150 kV, and it is smaller than HIBP system for LHD whose energy is up to 3 MeV. Adapting theoretical calculation for high acceleration voltage, we get information of charge exchange process in tandem acceleration system. Consequently, an Au^+ beam of LHD-HIBP can be optimized for plasma diagnostics.

A Faraday cup was set at end chamber of tandem acceleration system in Kobe Univ. It consists of a collector, pair of Sm-Co magnets, and an entrance aperture, and polyethylene sheet was set around aperture to observe a beam shape with video camera system. In order to measure the preliminary characteristics, hydrogen beams were used. At first a hydrogen beam was focused on polyethylene film around entrance aperture of the Faraday cup. Then the beam was moved to entrance aperture of the Faraday cup by the bending magnet. Secondary electrons are suppressed by the Sm-Co magnets. To increase suppression efficiency, the Faraday cup was biased at positive 240 V by a battery. A beam current was not changed whether the Faraday cup was biasing or not. Consequently, the secondary electrons were well suppressed by the Sm-Co magnets around the Faraday cup. The suppression was effective for various incident beam energies and ion spices.

Fig. 1 shows the experimental results for measurement of beam current on the tandem accelerator in Kobe Univ. The horizontal axis indicates average value of ionization gas gauge (IGC) in Low Energy and High Energy beam line, and the value is corrected for a measurement with Ar gas considering IGC sensitivity. Positive beam current measured with the Faraday cup is divided by charge state and Low Energy Faraday Cup (LEFC) current, then, the vertical axis indicates the normalized current in particle-nA/nA. The gas pressure dependences of Au^+ ion beam current were measured with the Faraday cap. All incident energy for negative gold ion beams were 150 keV, and those beams generated 280 keV Au^+ beam and 410 keV Au^{++} beam. N_2 and Ar gas were used for target gas. Fig. 1 shows that Au^+ ion beam current with N_2 gas target was larger than Au^{++} ion beam, and a peak pressure of Au^{++} ion beam is slightly larger than the Au^+. The results agree with theoretical calculation. Au^+ ion beam current with Ar gas target was a factor of two smaller than the current with N_2 target.

As these results are only preliminary, more experimental data is needed for our study, and there are many subjects to be considered. At first, a gas thickness, *NL*, is not calibrated. In our system, it is difficult to measure original negative gold beam on the Faraday cup in end chamber because of small transmission of negative gold ion beam especially introducing charge exchange gas. Therefore, beam attenuation method, describing in ref 3, is not employed to measure gas thickness in a cell. It is impossible to detect all ions in whole system. If gas spices and gas thickness in a gas cell are changed, effect of scattering process for an Au^+ ion beam is also changed. Therefore, it is important to treat scattering ions in detail. Consequently, it is necessary that those experimental results combine with the experiments on LHD-HIBP through theoretical calculations in future.

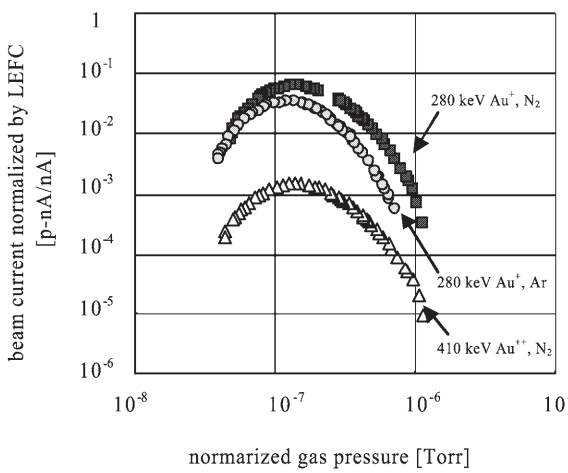

Fig. 1. Ion beam current dependence on gas pressure.

1) Ido, T. et al. : Rev. Sci. Instrum. 77, 10F523(2006)
2) Nishiura, M. et al. : Rev. Sci. Instrum. 79, 02C713 (2008)
3) Anna, M. M. S. et al. :Plasma Phys. Control. Fusion 51 (2009) 045007(9pp)