§28. 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 expand applied range of the heavy ion beam probe measurement on LHD, it is important to increase the probing beam current. 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 carry out a charge exchange experiment in variations of gas species and gas pressure in a gas cell of LHD-HIBP. The measurement can be carried out at the tandem accelerator of Kobe University in which to change gas species, gas pressure, and beam energy can be easy. But the terminal voltage is limited to 150 kV because momentum of MeV Au ion is too large to be bent by a bending magnet, or the SW magnet. And the Au^- energy is much smaller than Au^- of LHD-HIBP system (up to 3 MeV). So, a theoretical model for electron stripping and capture at a gas cell, which has the dependence of the cross sections on ion energy in collision, is constructed, then the values between accelerators such as cross sections can be compared with this theoretical model. Consequently, an Au^+ beam of LHD-HIBP can be optimized for plasma diagnostics.

Fig. 1 shows the experimental results of beam current dependence on a gas pressure for various gases. H_2, He, Ne, N_2, Ar, and Xe gases were used as target gas in these experiments. The horizontal axis indicates gas pressure of ionization gas gauge at High Energy beam line (HE IGC), and the value is corrected by gas sensitivity. Positive beam current measured with the Faraday cup is divided by the charge state and the current of Low Energy Faraday Cup (LEFC), then, the vertical axis indicates the normalized current in particle-nA/nA. All incident energy of negative gold ions at collision were 150 keV, and those beams generated 280 keV Au^+ ions and 410 keV Au^{++} ions. The peak values of normalized current were almost same value, the differences are within a factor of two. The normalized gas pressure at the peak was large for small target atom.

Because a pressure gauge is not installed on a gas cell part of tandem accelerator in Kobe University, the pressure is estimated from a value of HE IGC. Therefore, we have to know a relationship between the gas pressure at a gas cell and the pressure at HE IGC with some kind of methods. A pressure calculation with conductance of vacuum component is one of a method to estimate the relationship. As the tandem accelerator has a turbo molecular pump at the gas cell to recycle target gas, it is difficult to calculate conductance near the gas cell. Then, a beam attenuation method was applied to estimate the relationship. 21 keV He^+ ion was used in this experiment. Beam attenuation curve was obtained under known ionization and recombination cross section, and the relation between gas thickness, *nl*, at the gas cell and pressure at HE IGC was obtained. Using this relation, the cross sections were estimated. An Au^+ fraction has a peak at gas thickness that is factor of four smaller than in Ref. [2]. Comparing the cross sections obtained by our measurement and the values described in Ref. [3], the former is ten times smaller than the latter. This is because the gas thickness is not determined in good accuracy. Thus, the absolute value of cross sections cannot be discussed at present.

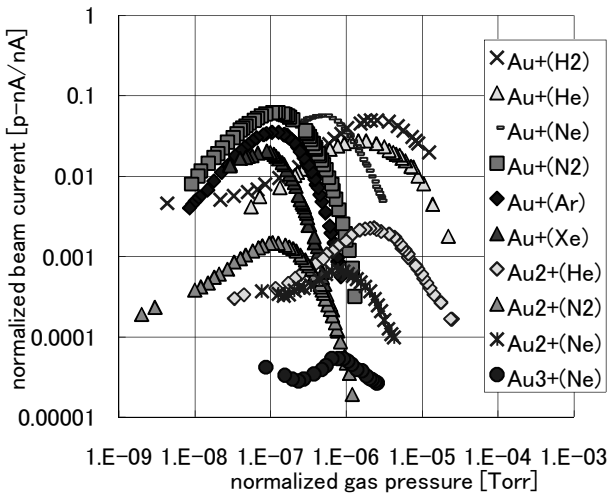

Fig. 1. Positive gold ion beam current dependence on gas pressure for various gases. The pressure is corrected by a sensitivity of ionization gas gauge, and the current is normalized by negative gold current at LEFC and an ionic charge.

In future work, a measurement of gas pressure at a gas cell is essentially needed. The pressure can be measured by BARATRON which can measure the absolute value (no sensitivity of gas species). Then, the absolute value of gas thickness is determined in a high precision by the result. If the detection of negative ions and neutrals can be detected, some cross sections are obtained. Various cross sections are obtained from those experimental results. Optimizing gas thickness and/or species at a gas cell with these cross sections, an Au^+ beam current of LHD-HIBP can increase. Then, LHD-HIBP can be applicable for high density plasma diagnostics.

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)