# §22. Study on Utilization of Heavy-metal-ion-beams for LHD-HIBP System

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The heavy ion beam probe (HIBP) is one of a method of plasma diagnostics, which can measure the potential profiles in plasma. An HIBP system has been installed at the Large Helical Device (LHD-HIBP) [1)]. In recent HIBP diagnostics, the current of the heavy ion beam is sufficient for the electron density of $10^{19}$ $m^{-3}$. Since the attenuation of the probe beam is severe in higher density plasma, larger $Au^+$ current is necessary. Some studies investigating how to increase the current have been done [2, 3)]. These objectives are to increase the negative ion beam current and to improve the charge exchange efficiency in the gas cell of the tandem accelerator, the beam transport efficiency, and the detection efficiency of ejected ions and so on. Especially, the experimental study to optimize the gas cell for high charge exchange efficiency is not easy using LHD-HIBP because it takes much time to change gas species in the gas cell. We have studied on the subject using a tandem accelerator at Kobe University [3,4)]. The accelerator has a gas cell, and the terminal voltage is up to 1.7 MV.

The current of the Au ions from the tandem accelerator can be measured by a Faraday cup. We try to observe the beam profiles. The experimental set up is shown in Fig. 1. The glass is set on a side of the Faraday cup. A beam profile is observed after the Faraday cup is turned by $\theta$ axis motor. If the beam is focused on a glass, then the luminescence reflected by a mirror can be observed by a camera. To measure the current by a MCP system, the Faraday cup system can be moved out by a $z$ axis motor driven system.

A luminescence of a beam spot was observed by this system. Because the size was mm order, whole ions could be detected by the Faraday cup. The gas thickness dependence of the Faraday cup current was measured. An example of the result is shown in Fig. 2. In this experiments the Faraday cup was not biased. The currents included the current of the secondary electron emitted from the surface of the Faraday cup. The charged particle can be swept out by a magnetic field. For this purpose, a bending magnet which select the beam course was used. Fig. 3 shows dependence of the measured currents on the gas thickness when the ions were swept out. The current contained only the current of the secondary electron which are emitted by the neutral Au incidence. If the secondary emission rate is known as a function of incident Au energy and the charge state, charge fraction is roughly obtained by this method. Combining this system and a conventional MCP measurement system which can move $x$-$y$ direction, the charge fraction dependence on the gas thickness can be measured, and the experiments to increase the $Au^+$ currents can be conducted.

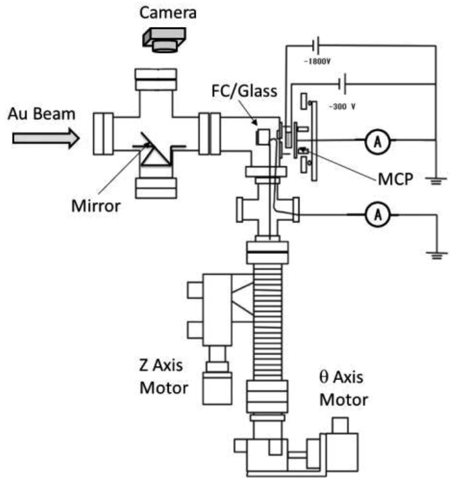


Fig. 1. Experimental set up for Au ion beam measurement.

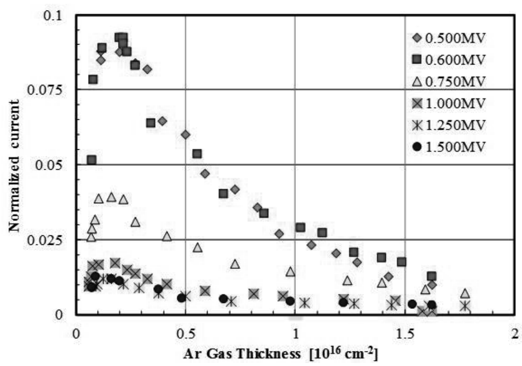


Fig. 2. Dependence of the ion / neutral beam current on the gas thickness.

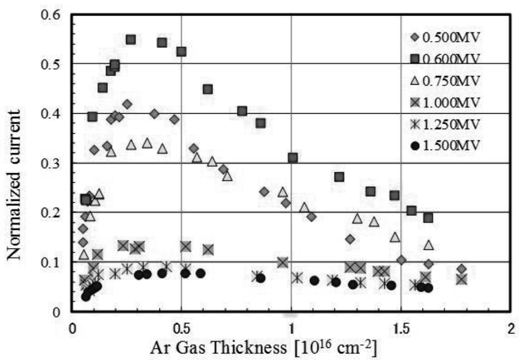


Fig. 3. Dependence of the neutral beam current on the gas thickness.

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3 Taniike, A. *et al*., Plasma Fusion Res. 5, S2087 (2010).
4 Taniike, A. *et al*., Plasma Fusion Res. 8, 2401087 (2013).