§4. Generation of Probe Beams for Plasma Diagnostics from a Thermal Contact-Ionization Plasma Source

Murakami, K., Tsukahara, H., Yoshimura, H., Fukuura, Y., Hara, J., Katsumata, I. (Osaka City Univ. Fac. Eng.)

The purpose of this study is to develop a beam probe diagnostics for the measurement of distributions of electric and magnetic fields of hot and dense plasma of $T_e \gtrsim 1$ keV and $n_e \gtrsim 10^{13}/cm^3$. The system is composed of an alkaline-earth atomic beam and a laser induced fluorescence spectroscopy(LIFS). Because either of atoms or singly charged ions of alkaline-earths have so called resonance lines in visible or ultraviolet region, LIFS can be applicable. The use of the neutral atomic beam is to avoid the effect of an intense magnetic field. A beam energy of the order of 100 keV may be enough. The informations on the electric field and the magnetic field are carried out by spectral lines by their Doppler shift and Zeeman effect.

This report is a summary on the research made in the 1993 fiscal year. The report also includes results on the generation of Tl^+ and Li^- beams for plasma diagnostics by a similar structure beam source.

As first candidate of the probe beam, a Ba atomic beam has been selected from the easiness of its generation. The target of the development of the beam has been tentatively aimed at to generate a 100 μA, 40 keV atomic beam. This has already been realized by means of a combination of an ion beam source using a thermal contact ionization plasma source and a Li vapour cell for the neutralization of beam ions by charge exchange reaction.

On the beam generation, a review will be found in the reference 1). The plasma source is the inside volume of a white heated Re foil cylinder of 5 mm in diameter inserted into a W pipe 7 mm in diameter and 20 mm in length. The ion beam is extracted from the one end of the cylinder. The beam material vapour is supplied from a material reservoir to the another end of the cylinder. The Re cylinder can be heated up to 3000K by means of the electron bombardment (~500 W) on the protecting W cylinder.

The energy spread is one of most important quality of the generated probe beam because it determines the limit of the accuracy of measurement. The energy spread of the neutralized beam atoms may be caused at the charge exchange in the piled-up positive potential due to the accumulation of slow Li^+ ions resulted in the charged exchange in the Li vapour cell. Because the amount of the energy spread depends very critically on the state of the charge exchange cell, the direct measurement is necessary for the beam energy spread.

An optical system which is attached to the the beam generating system has been constructed. A Xe arc lamp or a dye laser is used for the luminescence excitation and a Fabry-Perot interferometer for measurement of Doppler width of spectral lines. The measurement should be made longitudinally along the beam axis. The beam source is an intense light source because of its temperature. Considerable effort has to be paid to eliminate this background light. It has been weakened to an intensity tolerable in actual measurement.

In a test generation of Tl^+ beam, a current of 370 μA has been obtained using TlI as beam material.

The generation of Li^- beam has been studied by a beam source system modified by an Cs reservoir for the introduction of Cs vapour into the plasma generator. As a preliminary result, an amount of 95 nA Li^- current has been obtained.

Reference:

1) Katsumata, I. et al. : Rev.Sci.Instrum. 65(4), PartII, (1994) 1392-1394.