§15. Generation of Probe Beam for Plasma Diagnostics from a Thermal Contact-Ionization Plasma Source

Murakami, K., Fukuura, Y., Kawaguchi, G., Tanaka, Y., Katsumata, I. (Osaka City Univ. Fac. Eng.)

The purpose of this study is to develop two kinds of probe beam sources for fusion plasma diagnostics. [1] The first one is for the electric and magnetic fields measurement and the second one is for the α -particle diagnostics.

The first method is a combination of a probe beam and laser induced fluorescence spectroscopy (LIFS). The probe beam to be used is an energetic alkaline-earth atomic beam to avoid the effect of plasma confining magnetic field. Information of electric and magnetic fields are obtained by LIFS from the Doppler broadening and the Zeeman effect of fluorescence of a spectral line of singly ionized probe ions which are ionized in the plasma to be measured. Either of atoms or singly ionized ions of alkaline-earths have resonance lines in visible or near ultraviolet region. A Ba beam is selected by easiness of its generation.

A Ba^+ beam is generated in a thermal contact-ionization plasma source and is neutralized by charge-exchange reaction with Li atoms in a Li vapor cell. The plasma source is consist of a Re foil cylinder 5mm in diameter inserted into a 20 mm long W pipe. It can be heated up to about 3000K by electron bombardment. The Li vapor cell has a structure similar to the heat pipe. No pumping system is necessary for the cell. A 100 μA , 40keV Ba beam has been obtained already. The energy spread of the beam is an important factor to determine the accuracy of the electric field measurement. It may be broadened in the Li cell due to momentum transfer collisions with Li atoms and the electric potential distribution due to the accumulation of charge exchanged slow Li^+ ions in the cell. In the present study, the measurement of the energy spread is under the way by means of the optical Doppler broadening measurement. A Fabry-Perot interferometer is used in the measurement. A 500W Xe arc lamp is used for the excitation of the fluorescence. The light from the 3000K plasma source interfere so severely that any definite spectral line measurement can not be possible. To improve the situation, several viewing damp systems have been tested. Recently, the back ground light has been reduced to the value compatible with the signal light and the optical measurement has become possible. As a preliminary result, the energy spread of several keV for a 30keV primary Ba^+ beam has been measured under a high Li vapor pressure. The result may be explained by the momentum transfer between Ba atoms and Li atoms. To obtain narrower energy spread, the beam must be neutralized under a significantly lower Li vapor pressure.

For the α - particle diagnostics, the development of a Li^- ion beam source is under the way using the similar ion beam source as above. As the beam material, Li metal is used.An additional reservoir has been attached to the beam source to supply Cs vapor into the source plasma as usual in negative ion production. The electron separation from negative ion beam is made by a vertical magnetic field applied by a small iron-core electromagnet attached to the outlet of the final accelerating electrode. A negative ion beam current about 2μA has been obtained. In the metal Li used as the beam material, 1 % order impurity of other alkalis are included. The mass analysis study of produced negative ion beam is under the way by means of a time-of-flight mass analyzer. It is very likely that heavier elements appear at first after the charge of the new beam material into the reservoir, and, then the species become lighter elements and finally to converges to Li^-.

Reference

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