§19. Diagnostics of Plasma with Negative Ions Using the Eclipse Laser Photodetachment Method in Divertor Simulator MAP-II in the Univ. Tokyo (NIFS04KOAB009)

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A probe-assisted Laser photodetachment (LPD) method has been applied for the measurement of negative ions in linear divertor plasma simulator MAP-II in the University of Tokyo.1) We have revealed that the probe surface adsorbates released by the irradiation of a laser pulse can disturb the measurements. 2)

For the purpose of avoiding this probe surface ablation, we have proposed a method, "eclipse" laser photodetachment method (Eclipse-LPD) (Fig. 1).3) The name comes from the lunar eclipse in which shadow of the earth (wire) protects the moon (probe) from direct irradiation of the sunlight (laser beam).

Moreover, the method yields direct measurement of sheath thickness around the probe tip and the minimum laser diameter to supply photo-detached electrons, which is often referred to as “collection region of photo-detached electrons”, which are important in validating the applicability to magnetized plasmas.

The MAP-II consists of a dc arc source, a source chambers for differential evacuation and a target chamber.

The electron density n_e and the temperature T_e at the center of the plasma column in the target chamber are about 10^{12} cm^{-3} and 5 eV, respectively, while those at the peripheral region (r ~ 5 cm) are about 10^{11} cm^{-3} and 1 eV, respectively.

Temporal evolutions of the excess electron current for conventional LPD and Eclipse-LPD are compared in Fig. 1(b). Shift of the peak position corresponds to the travel time of the photo-detached electron swarm to the sheath edge across the shadow region. Therefore, the sheath width can be estimated from the waveform.

By making use of the waveform of the Eclipse-LPD signals, we can evaluate the sheath thickness around the probe in three independent ways. Details of this method are described in ref. 4. The electron sheath thicknesses deduced from the three processes are plotted in Fig. 2. These values show good agreement with each other. The theoretical sheath thicknesses using Child-Langmuir (CL) law for plane-parallel and cylindrical geometry are also plotted in Fig. 2. The experimental values are much thicker than that calculated based on the cylindrical CL theory, and close to that base on the plane-parallel CL theory, especially at the probe-bias voltage higher than about 50 V.

This result suggests that the shape of the sheath is distorted by the magnetic field and that it behaves more as plane probe rather than cylindrical one, although the field is not so high.

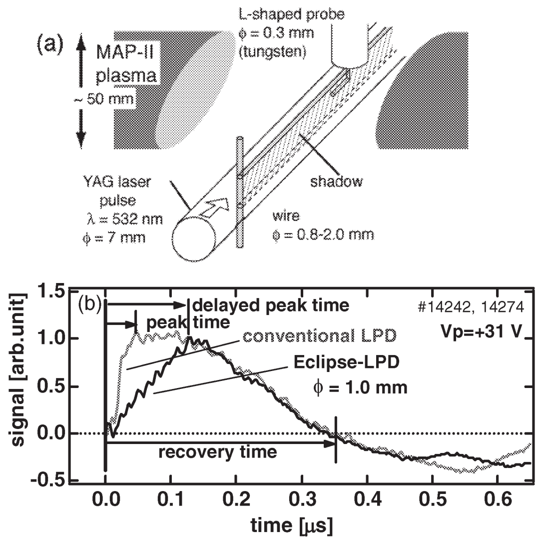

Fig. 1 (a) Schematic view of experimental setup for Eclipse-LPD. (b) Waveforms of the signal from conventional and Eclipse LPDs.

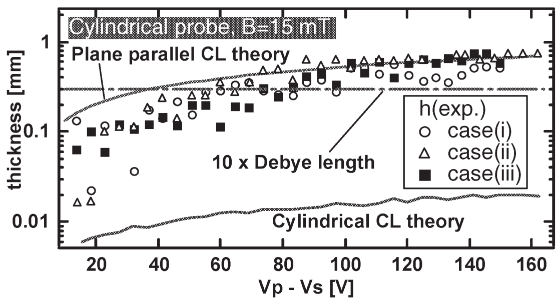

Fig. 2. Thickness of the electron sheath around a cylindrical probe at 15 mT, deduced from independent ways, (i), (ii) and (iii). Theoretical thicknesses of plane-parallel C-L sheath and cylindrical C-L sheath (solid lines) and Ten times the Debye length (dashed line) are plotted for comparison. Diameter of the wire used is 2 mm.

Reference

1) Kado, S. et al. : J. Nuclear Mat. 337–339 (2005) 166
2) Kajita, S. et al. : Contrib. Plasma Phys. 44 (2004) 607
3) Kajita S, et al. : Phys. Rev. E 70 (2004) 066403
4) Kajita S,.et al.,: Plasma Sources Sci. Technol. 14 (2005) 566