§28. Study of Pellet Ablation by Imaging Spectroscopy Method Using Optical Filter

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To investigate the physics of pellet plasmoid (ionized ablation cloud) dynamics, internal distribution measurements in a pellet plasmoid by high-speed imaging spectroscopy have been demonstrated in the Large Helical Device (LHD). The behaviour of the plasmoid is complicated due to its interaction with the background plasma and the magnetic field etc. In this study, the effect of the background plasma on the pellet ablation is experimentally investigated.

The pellet ablation and subsequent behaviour of the dense plasmoid are key elements to determine the characteristics of pellet refuelling. In LHD, the electron density distribution of the plasmoid was obtained by imaging measurements using a bifurcated fiberscope [1]. Here, it was assumed that the electron temperature of the plasmoid is in the limited narrow range. To evaluate the internal distribution precisely and also to understand the ionized state of the plasmoid, it is essential to identify not only the electron density but also the electron temperature of the plasmoid. In this study, we apply a fast imaging spectroscopy with high spatiotemporal resolution using a five-branch fiberscope ($15,000 \times 5$ fiber elements) and a fast camera (20,000 fps) to identify both the electron density and temperature distributions in the plasmoid. The spectra of hydrogen Balmer-lines and background continuum radiation are determined by the electron density and temperature of the plasmoid. The spectra can be estimated from the intensity ratio measured using different narrow-band optical filters. In the five-branch fiberscope used in this study, each objective lens has a different narrow-band optical filter for the hydrogen Balmer lines and background continuum radiation. The electron density and temperature in a plasmoid can be obtained from the intensity ratio measured with these filters.

In addition to the imaging measurements, the spectroscopy measurements using the photodiode with narrow-band optical filters are mutually conducted.The photodiode measurement has no space resolution but high temporal resolution with 1 μsec. It should be noted that the averaged electron density and temperature in the plasmoid are evaluated. Figure 1 shows the time evolution of (a) the intensity through the optical filters and the ratio, and (b)the electron density and temperature in the plasmoid. The electron density of the plasmoid is increased as the ablation progressed. The electron temperature of the plasmoid is slightly increased at about 1eV, indicating that a weakly-ionized plamoid is observed.

Figure 2 shows the results of imaging measurements in the case of (a) high and (b) low background temperature plasma. The electron density inside the plasmoid at higher background temperature plasma is large. The result is consistent with the higher ablation rate at higher background plasma.

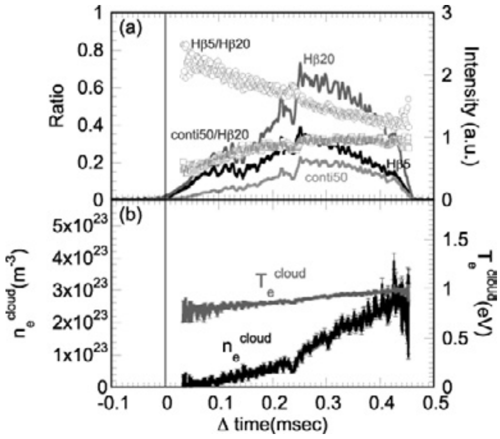

Fig. 1: The time evolution of (a)each intensity through the optical filters and the ratio and (b)the electron density and electron temperature in the plasmoid. Δ time is the elapsed time of pellet ablation.

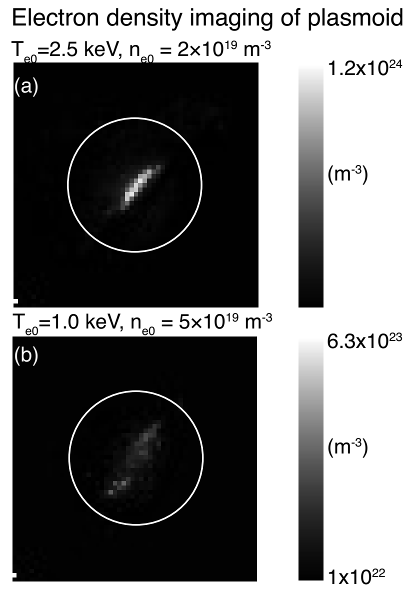

Fig. 2: The typical images of electron density of the plasmoid in the case of (a) high and (b) low background temperature plasma. The plasmoid is shown in the circle.

1) G. Motojima et al., Plasma. Fusion Res. **5**, S1033 (2010).