§64. Studies of Neutral Beam Attenuation on a Discharge with Impurity Pellet Injection

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I had reported that carbon pellet injection affects increasing of neutral beam attenuation in the past report. Beam deposition rate increased over 80% after small carbon pellet injection, then the carbon fraction immediately decreased under 0.5% during high ion temperature[1]. In the following, we found a different attenuation behavior in the case of tungsten impurities.

We used a cylindrical carbon pellet (C-pellet) and carbon and tungsten mixture pellet (CW-pellet) with the size of 1.2 mm diameter and 1.2 mm height. Tungsten powder was filled in a cylindrical carbon pellet cored with 0.4 mm diameter and 0.7 mm depth. Figure 1(a) shows the averaged electron density measured by far infrared ray interferometer on the discharges without pellet, with C-pellet and with CW-pellet. Electron densities rapidly increased to $2.4 \times 10^{19} \mathrm{m}^{-3}$ after C-pellet injection then it decayed to the same density level at t=4.05s. In the case of CW-pellet, we have observed slowly increasing of electron density as twice large as C-pellet case after first density jump, which increasing would be caused by tungsten ionization. Electron temperature (T_e) measured by Thomson scattering was seriously affected by CW-pellet as shown in Fig. 1(b). The electron temperature decreased to 1 keV at 4.2s, after that it was recovered to 3 keV with density decreasing.

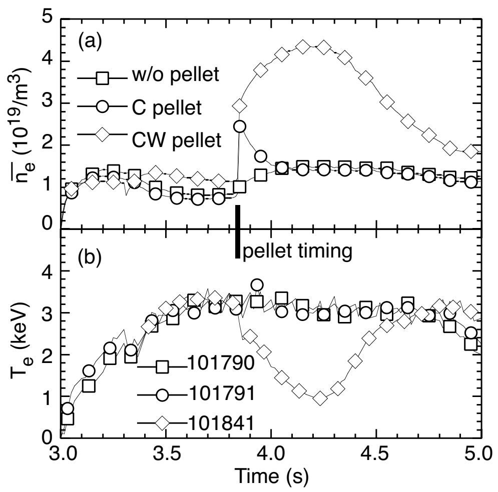

Fig. 1: Time evolution of the averaged electron densities (a) and the electron temperatures (b) on the discharges without pellet (square), with carbon pellet (circle) and with carbon and tungsten mixture pellet (diamond).

Figure 2(a) shows the intensities of hydrogen Balmer-α (H_α) spectrum emitted from neutral beam particles. Beam emission H_α spectrum could be separated from background H_α by Doppler spectroscopy, and its intensity was proportional to the product of residual beam density and electron density[1]. So a beam emission H_α became weak illumination under the condition of strong beam attenuation. At the discharge without pellet injection, we observed constant beam emission H_α intensity as shown square marks in Fig. 2(a). The temperature rise of a molybdenum thermal analysis cup set on a beam armor tile increased during beam injection as shown in Fig. 2(b). Sudden signal drop was observed on beam emission H_α in the case of carbon pellet, but it had recovered by 0.3 sec after the C-pellet injection. In this case, the Mo cup temperature decreased by beam attenuation but it was heated again by recovering beam shin through. This result was consistent to the beam attenuation scenario by impurity emission on the C-pellet discharge in LHD. On the other hand in the CW-pellet discharge, we had observed huge signal drop on the beam emission H_α, but it had never appeared even though the electron density was decreased. The temperature of the thermocouple on the armor tile decreased continuously after CW-pellet injection as shown diamond marks in Fig. 2(b). This result suggested that most beam particles were blocked by small tungsten impurities, and emission of tungsten impurities would be slow comparing with carbon impurities. So we need to investigate a detailed effect of tungsten because fusion plasma might be severely affected by tungsten impurities.

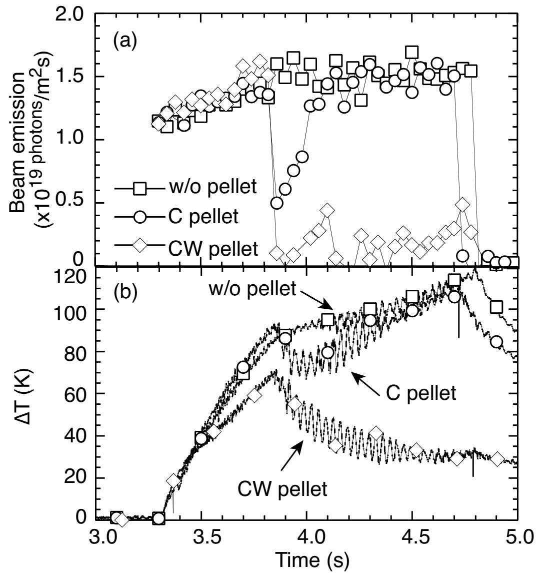

Fig. 2: Time evolution of the beam emission H_α signals (a) and the temperature rise of Mo cup on the beam armor tile for BL3 (b).

1) K. Ikeda *et al.*, J. Plasma Fusion Res. SERIES, Vol. 9, (2010) pp88-93.