§10. Initial Experiment on the Tracer-Encapsulated Cryogenic Pellet (TECPEL) Injection into LHD Plasmas

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In order to develop understanding of impurity particle transport in magnetically confined toroidal plasmas, a double-layered impurity pellet, a tracer-encapsulated pellet has been proposed 1). This idea has been realized first as a tracer-encapsulated solid pellet (TESPEL). TESPEL consists of polystyrene polymer ($-CH(C_6H_5)CH_2-$) as an outer shell and tracer particles as an inner core. Thus a very easy operation of loading and injecting the pellet has been achieved at room temperature, whereas the carbon from the shell of the TESPEL is an inevitable side impurity. In order to eliminate the side impurity from the tracer-encapsulated pellet, a tracer-encapsulated cryogenic pellet (TECPEL) has been developed 2). The shell of the TECPEL is made of ice of hydrogen the same as a fuel gas.

In the 9th LHD experimental campaign, the TECPEL injector, which is a pneumatic pipe-gun type injector, has been installed at Port 3-O of LHD. The installation of the TECPEL injector has been completed in a short time, since the TECPEL injector shares a part of guide tubes, a differential pumping system and a pellet monitor with a 10 barrel normal hydrogen ice pellet injector, and a part of the controlling system of the injector with the TESPEL injector. The size of the TECPEL, which is fabricated in the injector based on the in situ condensation technique, is 3 mm in diameter and ~ 3 mm long almost the same as the normal hydrogen ice pellet for plasma fueling (see 2) for more details). Figure 1 shows the typical signals from the pellet monitor with the TECPEL injection. The TECPEL velocity is obtained by measuring the time of flight between signals from a microwave mass analyzer and a light gate and is typically around 1 km/s. A large dip observed in the Hα emission from the TECPEL ablation cloud could be related to the major rational surface of unit, as reported in many experiments regarding the hydrogen ice pellet injection. The signals from the pellet monitor show that the integrity of the TECPEL is kept until the TECPEL enters the plasma. Figure 2 shows the temporal evolution of the LHD discharge with the TECPEL injection. In the figure, the TECPEL injection time (~ 2.73 s) is indicated as the vertical dashed line. In this shot, the tracer of the TECPEL is the carbon ball with a diameter of 0.2 mm. Just after the TECPEL injection, the line-averaged electron density, measured with the far-infrared interferometer, is increased by 63 %. The rapid increase of the intensity of C III (97.7 nm), which is measured using a 20 cm normal incidence VUV monochromator equipped with a secondary electron multiplier, could be attributed to the carbon tracer in the TECPEL. However, since the increase of the intensity of C III (97.7 nm) has been also observed, in some cases, even after the normal hydrogen ice pellet injection, the spectroscopic observation of the carbon from the TECPEL should be optimized. Nevertheless, the initial experiment of the TECPEL injection into the LHD plasma has been implemented successfully.

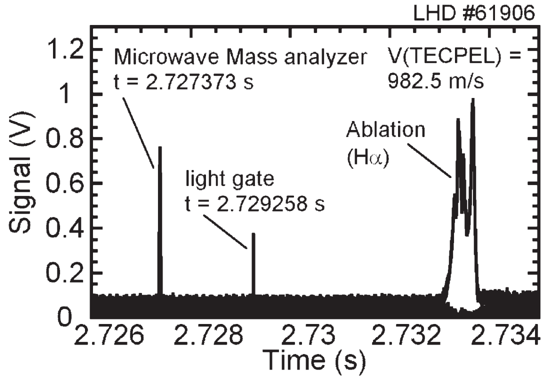

Fig. 1. Temporal evolution of the pellet monitor signals of the discharge with the TECPEL injection.

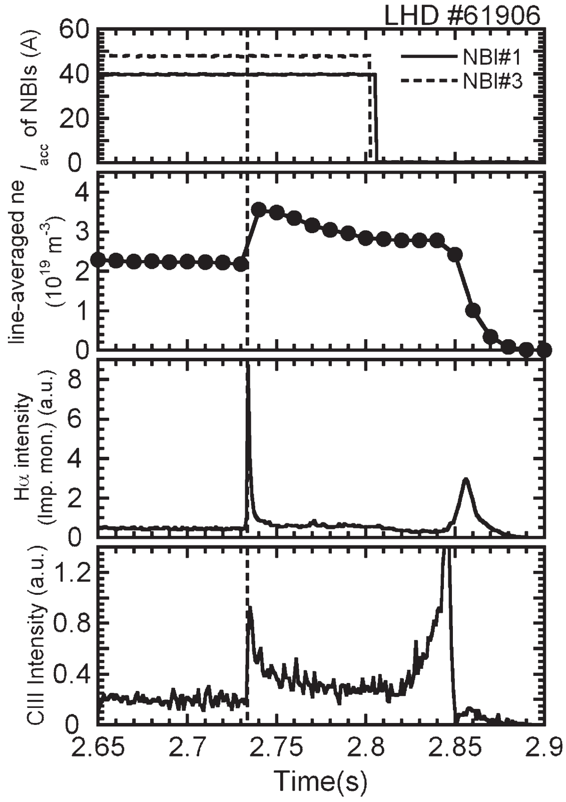

Fig. 2. Plasma waveforms of the LHD discharge with the TECPEL injection. The vertical dashed line indicates the TECPEL injection time (~ 2.73 s)

References

1) Sudo, S.: J. Plasma Fusion Res. **69**, (1993) 1349.

2) Sudo, S. et al.: Rev. Sci. Instrum. **76**, (2005) 053507.