§12. Recycling Effect on the Ion Temperature in LHD NBI Plasma

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i) Introduction

With the high power heating devices high ion temperature (T_i) plasma over 5 keV has been obtained in the NBI heated plasma in LHD. Additional NBI heating using vertical injection system of positive hydrogen increased T_i more than 6 keV. This high T_i plasma has been achieved due to the improvement of heat transport in the core region. However, there are some experimental data suggesting that the low recycling wall is one of the important conditions to obtain the high T_i plasma.[1)] Since the neutral gas in the peripheral region hard to affect the transport of the core plasma directly, it is thought to be the effect by the NBI heating.

The purpose of this study is to examine the influence of the neutral gas pressure in the peripheral region to the high T_i plasma and to clarify the relation to the NBI heating.

ii) Experimental results and discussion

In the high T_i experiments, a helium glow discharge, baking, and titanium gettering are usually performed before experiments in order to keep the condition of low recycling from the wall. It tends to obtain a high ion temperature plasma during one hour after the treatment of wall condition.

Figure 1 shows a typical waveform of gas pressure in the vacuum chamber, line-averaged density and central ion temperature at the high T_i discharge with carbon pellet injection. High T_i was achieved after the pellet injection as shown in the figure.[2)] In order to reveal the effect of recycling on the achieved central ion temperature, the behaviors of background neutral gas pressure and line averaged density were investigated. The pressure P_0, P_{min} and the density n_{e1}, n_{e2}, n_{e3}, n_{eC} and n_{eTmax} correspond to those observed at the several timings in a shot indicating in Fig.1 These data are plotted as a function of T_{imax} of each shot in Fig.2. As the ion temperature changed, they were almost kept at constant. However, maximum density at the breakdown n_{e1}, minimum density after the breakdown n_{e2} and minimum pressure in the chamber P_{min} are required to be relatively low to obtain the high T_i over 6keV. These conditions were realized within thirty shots just after the treatment of wall condition. The decrease of n_{e1}, n_{e2}, P_{min} indicates low recycling rate from the wall, where high T_i plasma were obtained.

This study revealed the characteristics of background neutral gas pressure and plasma density depended on the recycling condition and played a role for the achievement of high T_i discharge for the first time in LHD. The question raised form this analysis is the large time delay between the period appearing high ion temperature and the period when the effects of low recycling condition were observed. To solve this question and to understand the effect of edge behaviors on the temperature in the core plasma, further investigations on the edge density behavior and fast ion deposition are necessary, which remains for the future investigation.

1) S. Morita, et al., Nucl. Fusion, **42** (2002) 1179.
2) K. Nagaoka, et al., Fusion Sci. Tech., **58** (2010) 46.

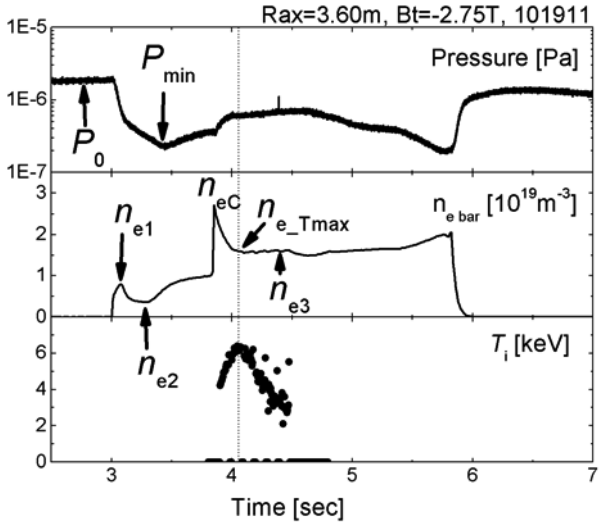

Fig.1 Temporal evolutions of gas pressure in the vacuum chamber, line-averaged density and central ion temperature at the high T_i discharge.

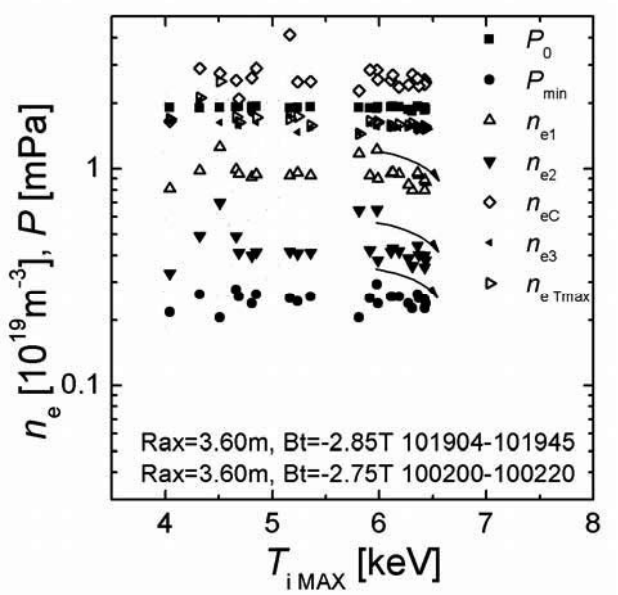

Fig.2 Pressure and line-averaged densities corresponding to each timing indicating in Fig.1 as a function of maximum ion temperature.