

§11. Enhancement of the Radiation Loss Experiments with the Impurities Puffing

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Reduction of heat and particle loads to divertor is a crucial issue to realize fusion reactor. Divertor detachment is a favorable operation for the purpose. To achieve divertor detachment, reduction of electron temperature (T_e) in scrape-off-layer (SOL) is necessary. In present medium/large fusion devices, plasma facing material has been carbon, and carbon works as dominant radiator for reduction of T_e . However, there are two disadvantages to use carbon as the plasma facing material in fusion reactor. They are large erosion and tritium retention. Therefore metallic material such as tungsten is considered to be plasma facing material in future fusion device, and it is considered that impurity such as neon seeding is necessary to enhance radiation loss in SOL. In tokamaks, impurity seeding experiment has been conducted, and reduction of T_e in SOL has been observed¹⁾. Against this background, impurity seeding experiment has been conducted in LHD which has unique magnetic field line structure such as existence of stochastic layer in SOL²⁾. To investigate the mechanism of the radiation enhancement and to explore the stable operation with the impurity seeding, N_2 , Ne and Kr were utilized as seeding gases in the experimental campaign in 2012. All the impurity puffing experiments, main working gas was hydrogen. Results of the spectroscopic analyses for N_2 and Ne puffing discharges are described in ref.3) and 4), respectively.

In the Ne puffing discharges, charge-exchange spectroscopy was conducted to measure the fully stripped Ne ion density profile. Modulated NB#4 was injected for the spectroscopy. Figure 1 shows time evolutions of the total radiation power in two discharges with different electron densities ($n_{e,bar} \sim 4 \times 10^{19} m^{-3}$ (#112917) and $6.5 \times 10^{19} m^{-3}$ (#112925)). The fully stripped Ne density profiles and electron temperature profiles during each discharge are also shown in Fig. 1. The heating power with tangentially injected NB was $\sim 8 MW$ (#112917) and $\sim 9.5 MW$ (#112925). The results can be summarized that the penetration of Ne is smaller in the lower density discharge, and the electron temperature is not sensitive to fully stripped Ne density. Ne density increased after the termination of Ne puffing. VUV spectroscopy measured highly ionized Ne emissions, and the time evolutions of them are depicted in Fig. 2. Figure 2 also shows that Ne emission increased even after the termination of Ne puffing, and it suggests that recycling rate of Ne is large and/or Ne is accumulated in core plasma. In the N_2 puffing discharges, total radiation increased with two steps as shown in Fig. 3. It is considered to relate to the edge electron temperature.

In the next step of this study, the contributions of the impurities and the intrinsic impurities (C, O) to the total radiation should be revealed.

- 1) Asakura, N. et al.: Nuclear Fusion **49** (2009) 115010.
- 2) Masuzaki, S. et al.: J. Nucl. Mater. to be published.
- 3) Suzuki, C. et al.: in this annual reports.
- 4) Murakami, I. et al.: in this annual reports.

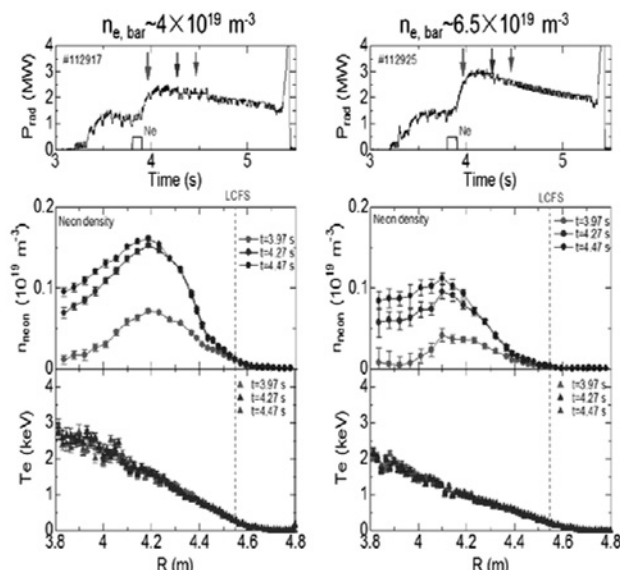


Fig. 1. Time evolutions of the total radiation power, and fully stripped Ne density and electron temperature profiles during two discharges with different electron densities.

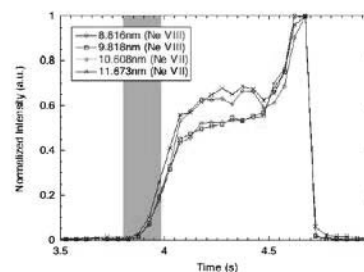


Fig. 2. Time evolutions of NeVII and NeVIII emissions during the discharge with Ne puffing (3.8 s-3.97 s).

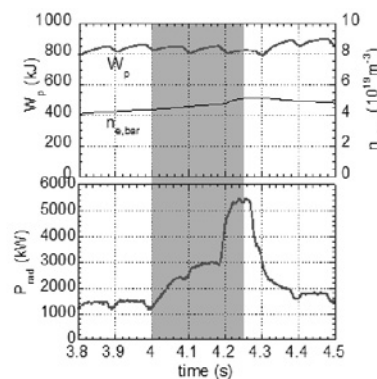


Fig. 3. Time evolutions of the stored energy, line averaged density and the total radiation in a N_2 puffing (the hatched time) discharge.