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§12. Ne, Ar and N_2 Seeding in LHD

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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 observed[1]. 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 SOL[2].

In 15th cycle experiment campaign, Ar and N_2 were utilized as seeding gases for radiation enhancement, separately. Figures 1 show time evolutions of stored energy (W_p), line averaged density (n_e), NBI power (P_{NBI}) and total radiation power (P_{rad}) in typical Ar and N_2 seeded discharges. The plasma responses to Ar seeding such as the changes of W_p, n_e and P_{rad} were similar to that in Ne seeding discharge[2]. P_{rad} reached its peak after the termination of Ar seeding. On the other hand, response of P_{rad} to N_2 seeding was different from that to Ne and Ar seeding. P_{rad} started to increase just after the beginning of N_2 puffing, and decrease immediately after the termination of the seeding. That suggests that N_2 recycling coefficient is much smaller than that of Ne and Ar, and this is also similar to that in some tokamaks, such as Alcator C-mod and ASDEX-Upgrade[3, 4]. The mechanisms of the low recycling are not clear up to now. Figures 2 show reconstructed radiation profiles[5] in Ar, Ne and N_2 seeded discharges, respectively, when P_{rad} reached maximum. In all discharges, intense radiation around the top X-point was observed. In the case of N_2 discharge, radiation inside LCFS was less than that in the other discharges. It is considered to be related to lower atomic number of N, low recycling and transport in the edge plasma region.

1) Asakura, N. et al.: Nuclear Fusion **49** (2009) 115010.
2) Masuzaki, S.: NIFS annual report 2010-2011 (2011)
3) Reinke, M.L. et al:. J. Nucl. Mater. **415** (2011) S340.
4) Kallenbach, A. et al.: J. Nucl. Mater. **415** (2011) S19.
5) Y. Liu et al.: Rev. Sci. Instruments **77** (2006) 10F502.

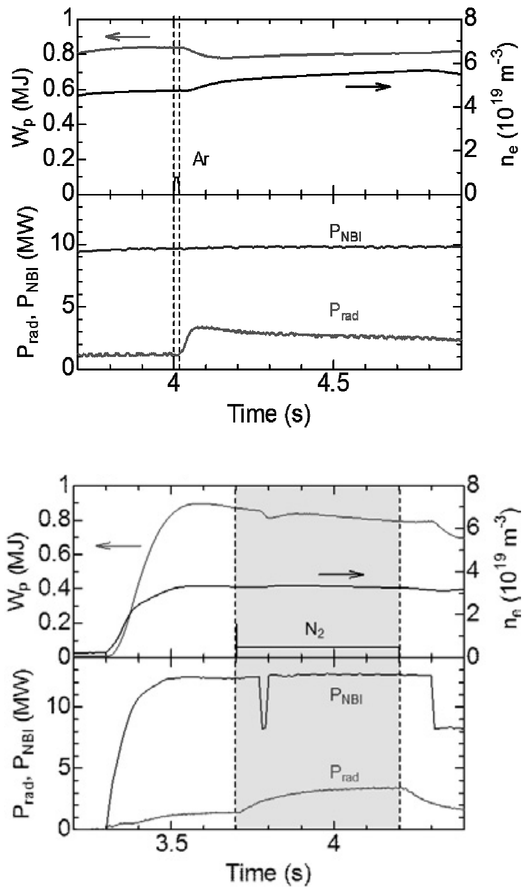

Fig. 1. Time evolutions of stored energy (W_p), line averaged density (n_e), NBI power (P_{NBI}) and total radiation power (P_{rad}) in typical Ar (top) and N_2 (bottom) seeded discharges, respectively.

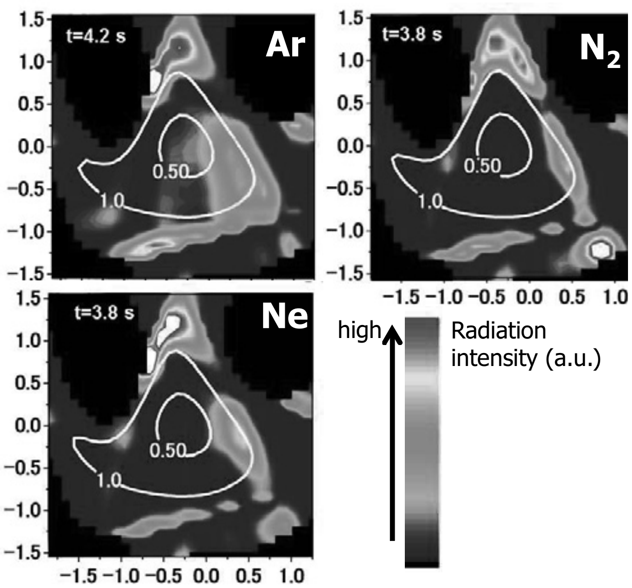

Fig. 2. Reconstructed radiation profile in Ar, Ne and N_2 seeded discharges, respectively, measured by AXUVD fan arrays[5] when P_{rad} reached maximum. Unit of horizontal and vertical axis is meter. White lines show $\iota/2\pi$=0.5 and 1 surfaces.