§8. Effect of Radiation Power Loss Due to Impurity Gas Puff to Divertor Plasma

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Reducing high heat load on divertor plates is one of issues to prevent serious damage of divertor plates in future fusion devices such as the ITER, a DEMO and a helical reactor FFHR[1]. Impurity gas injection into divertor plasma is one feasible idea to reduce the heat load on divertor plates, since impurity gas causes radiation power loss and decreases electron temperature, which would result in plasma detachment. There are several works considering the effect of impurity gas puff for scrape-off layer and divertor region for ITER[2,3] and JT-60SA[4] by using transport codes. Nitrogen, neon, argon, and other noble gases are the candidates for impurity gas injection.

We carried out theoretical calculations to examine the effect of impurity gas puff for peripheral plasmas using one-zone plasma modeling[5]. We found that Ne and N gas puff can reduce electron temperature down to a few eV within 1s if gas puff rate is high enough with 1% contamination rate. Dominant ionic states for radiation loss are different when electron temperature is different.

In the 16th LHD experimental campaign we injected impurity gas to the divertor region and measured extreme ultraviolet (EUV) spectra to examine how the impurity gas contributes to reduce electron temperature. Fig. 1 shows EUV spectra when N_2 gas was injected. N VI and N VII lines were observed. We use ADAS[6] for analyzing the intensity ratio. Recombination processes are not considered in the model and ionizing plasma is assumed. Fig. 2 shows calculated intensity ratios as a function of electron temperature. Using this relationship for N VI 2.91nm / 2.88nm, we can derive electron temperature from the measured ratio, as shown in Fig.3. Then, using the derived temperature, we can estimate ion density ratio n(N VII)/n(N VI) from the measurement (▽). This ratio agrees with the ion density ratio in ionization equilibrium (◇) only at t=3.925, and it does not agree at later time. This indicates the plasma where N VI and VII were emitting was not in ionization equilibrium and we need to consider non-equilibrium condition and recombination processes in future analysis.

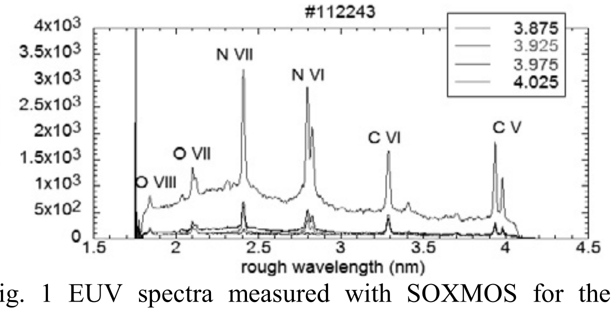

Fig. 1 EUV spectra measured with SOXMOS for the discharge #112243. N_2 gas was injected at t=3.8 – 3.9s.

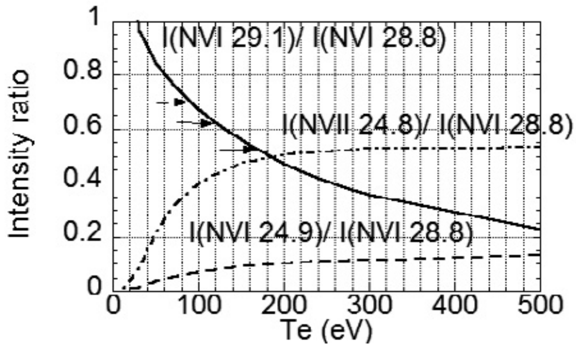

Fig.2 Spectral intensity ratios for N VI and N VII lines as a function of electron temperature. Ion densities are assumed to be equal for N VI and NVII in this graph. ADAS[6] is used for the calculation.

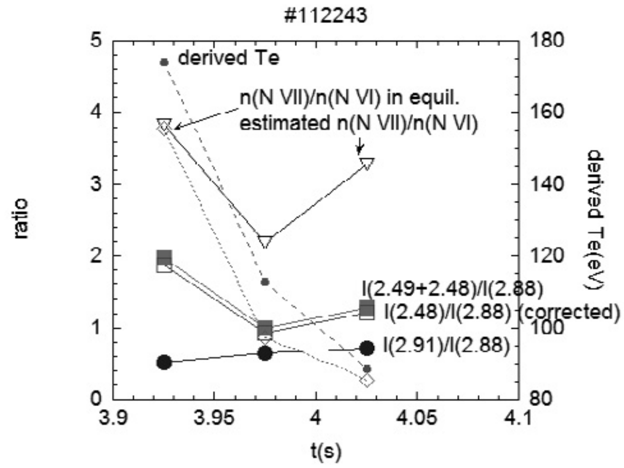

Fig.3 Temporal distribution of measured intensity ratios I(N VI 2.91nm)/I(N VI 2.88nm) (●) and I(N VI 2.49nm+ N VII 2.48nm)/I(N VI 2.88nm) (■), derived Te (small ● with dashed line), corrected ratio I(2.48nm)/I(2.88nm) (□), estimated ion density ratio n(N VII)/n(N VI) from line ratio (▽), and equilibrium ion density ratio n(N VII)/n(N VI) from Te (◇).

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