§10. Dynamic Behavior of Detached Recombining Plasmas under ELM-like Heat Pulse Irradiation

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A steady state, long pulse operation with a good confinement plasma, accompanying with a reduced divertor heat load is one of the key issues in the next generation fusion devices. It has been recognized that the ELMs associated with a good confinement at the edge, such as H-mode, must bring an enormous energy to the divertor target plate through SOL and detached plasmas. The understanding of the ELM energy transport through SOL to the divertor target is rather poor at the moment, which leads an ambiguous estimation of the deposited heat load on the divertor target in ITER.

In the present work the ELM-like plasma heat pulse is generated by rf heating in the frequency range of Whistler waves at a frequency of 13.56 MHz in a linear divertor plasma simulator NAGDIS-II. The electron-ion collisional damping of Whistler waves is expected to work for effective electron heating in a very low temperature plasma like detached recombining plasmas with Te < 1 eV. Just a small change of the electron energy distribution is expected to modify the properties of the detached recombining plasmas drastically as shown by a previous work.[1] The net rf power injected to the plasma is below 2 kW, and time behavior of the electron energy distribution and visible light emission from helium atoms are measured at different axial positions by fast scanning Langmuir probes and monochromator, respectively. The energetic electrons with an energy range of 10~40 eV are generated by rf heating in helium neutral pressure range above 3 mtorr. With increasing the helium neutral pressure to about 7 mtorr the electron temperature near the target plate decreases to less than 1 eV and the ion flux to the target is reduced to more than one tenth due to the strong recombination process. Figure 1 shows the response of the detached recombining plasmas on the heat pulse generated by rf heating at upstream in NAGDIS-II. The inverse ELMs which have been observed in JET[2] and ASDEX-U[3] for D_α emission are also found here to have double minimum in time for the Balmer series emission from low excited levels and strong reductions of spectral intensities from highly excited levels. These time behavior shows the transition from recombining to ionizing with rf heating and again back to recombining after switch-off of the rf pulse. From Fig. 1 it is indicated that the heat pulse, mainly due to energetic electrons, first ionizes the highly excited Rydberg atoms making the target ion flux increase, but no energetic electrons can reach the target due to a large ionization cross-section of Rydberg atoms. The excitation from the ground state starts after 50 μs, and the energetic electrons arrive at the target, decreasing substantially its floating potential. Such a dynamic behavior cannot be explained by the conventional CR model but motivates us to develop the time-dependent CR modelling. The detailed physical processes about the interaction between the heat pulse with conduction and convection, and detached recombining plasmas provide the ideas about the energy dissipation of ELMs through SOL including detached region.

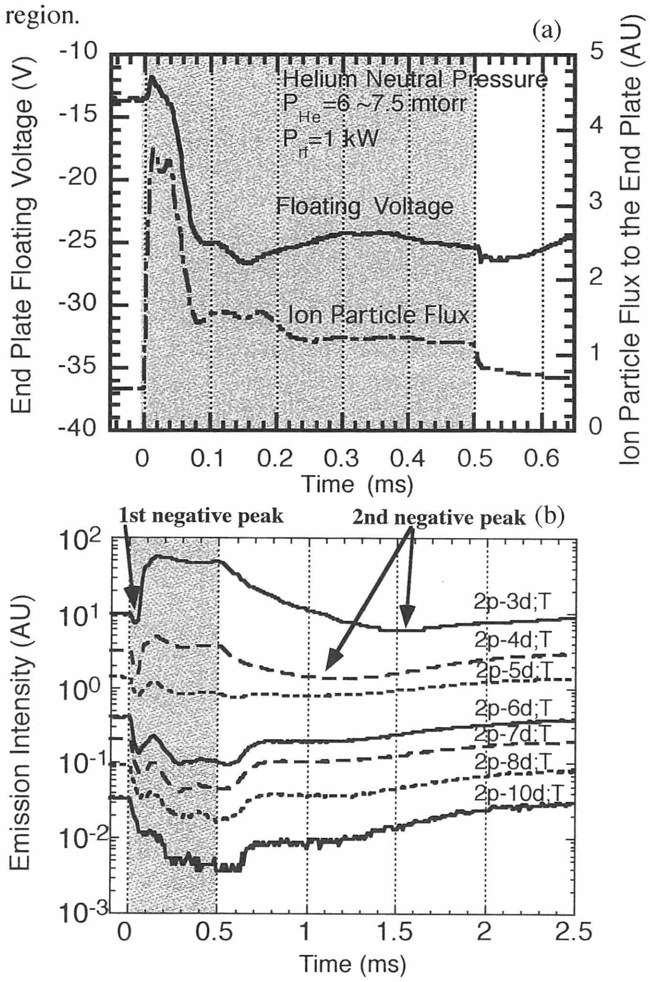

Fig. 1 Floating voltage and ion particle flux in the target end plate(a) and HeI line emission(b) during and after rf heating pulse. The rf pulse is applied at a hatched region in the figure.

References

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2) Loarte, A., et al., Nucl. Fusion **38**(1998)331.
3) Wenzel, U., et al., J. Nucl. Mater. **266-269**(1999)1252.