§7. Effect of Gas Species on the Macroscopic Oscillations of Detach Plasma in the TPD-II

Matsubara, A., Sato, K.
Sugimoto, T. (Dept. of Fusion Sci., Grad. Univ.),
Kawamura, K. (Res. Inst. Sci. Tech., Tokai Univ.),
Shibuya, T. (Dept. Elect. Photo. Opt., Tokai Univ.),
Tonegawa, A. (Dept. Phys. Sci., Tokai Univ.)

In closed divertor configurations, neutral particles leaking through the opening of the baffle can be reduced by so called "plasma plugging effect". The effect depends on the position of the detachment front, z_f. Therefore, z_f-stability is important for the reduction of the neutrals leaking. The macroscopic z_f-oscillation around the baffle was found in the linear machine, TPD-II (Test Plasma by Direct current) [1]. In this report the effect of species of gas injected into the divertor on the z_f-oscillation is presented [2].

As shown in Fig. 1, the experimental region is partitioned into the low-pressure region (called edge plasma region: region E) and the high-pressure region (called divertor region: region D) by means of the orifice that serves as the opening of baffle plates in magnetic confinement devices. The helium plasma flows from the region E and into the region D. The upstream electron plasma density n_e is $2\times10^{20}\,m^{-3}$ and the electron temperature is 5 eV under the axial magnetic field of 0.25 T. The neutral gas is injected into the region D for plasma detachment, flows against the plasma flow through the orifice, and is evacuated from the region E. The experimental results were obtained under the same experimental condition except the gas species injected into the region D.

Figure 2 shows how the oscillation begins to appear, as the flow rate of injected gas, Q_D, is increased. As Q_D is increased P_D and P_E increase, and ion saturation current drawn by probe 4, I_4, shown in frame (iv) decreases reflecting the movement of z_f toward the E region. At t ~ 350 sec for He (t ~ 400 sec for H_2), z_f appears to reach the position of orifice. Then, z_f suddenly comes into E region, and begins to oscillate between regions of E and D. Simultaneously the values of P_D, P_E, and $I_{1,4}$ oscillate. It can be seen that the amplitude of the oscillation is smaller for H_2 than that for He.

The detail behaviors of P_D, P_E, and z_f during the oscillation were described in Refs. 1 and 2. The typical phenomenon, i.e., when z_f comes into the region E, P_D decreases but P_E increases, appears regardless of the gas species, which is due to the common mechanism of the plasma-plugging depending on z_f.

Figure 3 shows the Q_D-dependency of ΔP (=P_D - P_E). The variation of ΔP has the upper limit, ΔP_{max}. Whenever ΔP reaches ΔP_{max}, z_f is located at the orifice. It can be considered that ΔP_{max} balances the plasma pressure, P_P, onto the inlet of orifice: $\Delta P_{max} \approx P_P$. Since the amplitude of the ΔP-oscillation should be less than the difference between ΔP_{max} and ΔP for without plasma indicated by dotted line in Fig. 3, P_P dominates the amplitude the oscillation. The value of ΔP_{max} for H_2 is smaller than that for He, indicating that as Q_D is increased P_P becomes smaller for H_2 than that for He. This is supported by the fact depicted in Fig. 2(iv) that the decrease in the ion saturation current I_1 is remarkable for H_2.

During the significant decrease in I_1 in the case of H_2, Fulcher-band spectra that is a measure of the Molecular Activated Recombination (MAR) is observed from the region E. The fast recombination by MAR is able to lose P_P rapidly. Therefore, there is possibility that the small amplitude of the oscillation for H_2 is owing to the MAR.

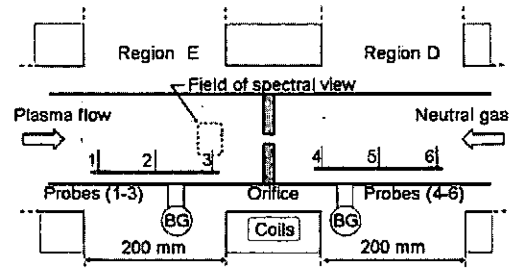

Fig.1. Schematic of experimental region of the TPD-II.

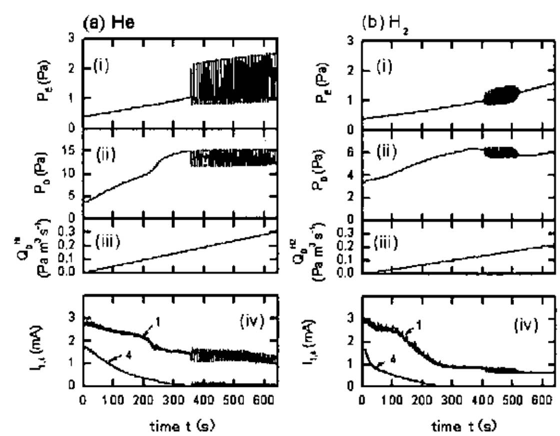

Fig.2. Long time-series showing appearance of the oscillation for cases of He (a) and H_2 (b).

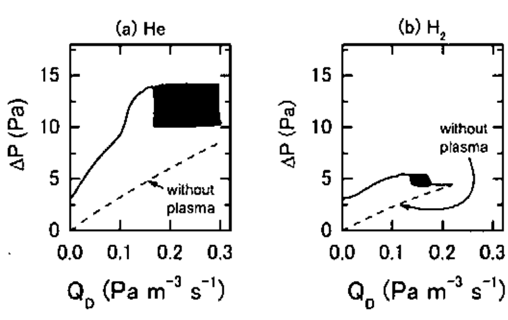

Fig.3. Q_D-dependency of ΔP (=P_D - P_E).

References
[1] Matsubara, A., et al., J. Plasma Fusion Res. 78, 196 (2002).
[2] Matsubara, A., et al., submitted to the J. Nucl. Mater.