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Hydrogen recycling study using a high temperature target in GAMMA 10/PDX tandem mirror

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Power and particle control is a key issue for a future fusion device. Divertor detachment is indispensable for reducing heat load on the divertor plate below the allowable level, and hydrogen recycling is an important player for the divertor detachment as well as particle control in steady state operation. Wall temperature plays a critical role on the hydrogen recycling. In the tandem mirror GAMMA 10/PDX, the hydrogen recycling study has been carried out by using a temperature-controlled tungsten target which is exposed to the end loss plasma [1, 2]. One of the features of GAMMA 10/PDX experiments is that neutral pressure during the plasma exposure is low enough to be able to measure emissions of the recycling particles.

A divertor simulation experimental module (D-module) is installed in the end region of GAMMA 10/PDX as shown in Fig.1. A V-shaped tungsten target is installed in the D-module and exposed to the end-loss plasma. The target plate temperature (T_{target}) can be increased up to 573 K by sheath electric heaters. Moreover, hydrogen gas can be supplied in front of the target.

When T_{target} was increased from room temperature to 573 K, the Balmer intensities in front of the target increased by a factor of ~2 to ~3 and the electron density at the target increased by 20~30 %, indicating enhanced hydrogen recycling due to increasing T_{target}. It is found that the increase in the Balmer intensities is much larger than that of the electron density, suggesting that electron impact excitation is not a primary cause of the significant increase in the Balmer intensities. It seems to be caused by production of excited hydrogen atoms by dissociation of vibrationally excited hydrogen molecules that are produced by the surface recombination (i.e. hot-atom recombination [3]). The vibrational temperature which was evaluated with a Fulcher-α band spectrum was in the range of 3,000 K to 4,000 K.

Moreover, effect of additional hydrogen gas injection in front of the target on the hydrogen recycling was examined. Figure 2 shows effects of the target temperature on the electron temperature and density in the case of the additional hydrogen gas supply. It is found that increase in the electron density is higher in the case of high temperature target than that of low temperature target, indicating the hot-atom recombination is enhanced also by the hydrogen gas supply.

References

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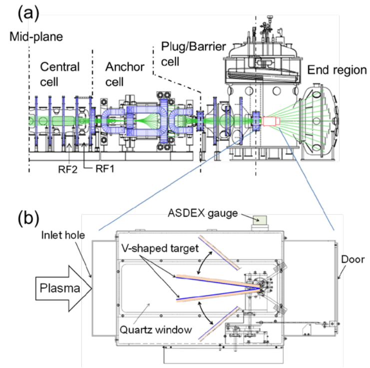

Figure 1. Schematic views of (a) GAMMA 10/PDX and (b) the D-module. The target size is 0.3 m in width and 0.35 m in length. The open-angle of the V-shaped base was 45 degrees in this experiment.

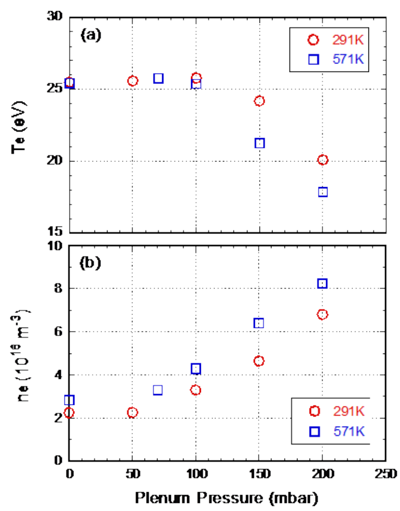

Figure 2. Dependence of (a) electron temperature and (b) electron density at the target plate on the plenum pressure, which is a pressure in the gas bottle that is above the piezo-electric valve for gas injection.