§31. H, D and T Quantitative Analyses for Plasma Facing Walls Exposed during Deuterium Experiment

Oya, Y., Chikada, T., Yuyama, K., Miyazawa, T., Fujita, H., Sakurada, S., Uemura, Y., Hu, C. (Shizuoka Univ.), Masuzaki, S., Tokitani, M., Yajima, M., Osakabe, M., Saze, T., Motojima, G., Satake, S., Hatano, Y., Yumizuru, K. (Univ. Toyama), Tanabe, T., Katayama, K., Otsuka, T. (Kyushu Univ.), Nobuta, Y., Matsumoto, Y. (Hokkaido Univ.)

1) Introduction

It is one of important issues to understand the behavior of hydrogen isotopes including tritium (T) in deuterium (D) plasma campaign at Large Helical Device (LHD). Quantitative evaluation of T in exhaust gas and retention of hydrogen (H), D, and T in plasma facing wall are essential for investigation of hydrogen isotope behavior. In addition, it is also important to elucidate how a fast triton produced by D-D fusion reaction was transported from plasma to plasma facing wall. In this study, Energy of implanted hydrogen isotope and impurities effect on hydrogen isotope retention was evaluated by development of hydrogen isotope thermal desorption spectroscopy (HI-TDS) system that can quantify all the hydrogen isotope (H, D, T) at the same time and evaluation of not only the amount of hydrogen isotope in plasma facing wall at LHD but also these three-dimensional distribution. In addition, the distributions of hydrogen isotope in poloidal and toroidal directions were clarified and T transport from plasma to plasma facing wall together with the orbital calculation of fast triton has been taken into consideration.

The objective of this study is to accumulate the knowledge for prediction of hydrogen isotope and alpha particle behavior in LHD.

2) Experimental

In this year, HI–TDS system which can measure all hydrogen isotopes have been developed as shown in Fig. 1. For H and D evaluation, an enclosed ion source attached with QMS (quadrupole mass spectrometer) which makes high sensitive measurement at atmospheric pressure was installed into HI-TDS. For T evaluation, the rest of gas was introduced into the ionization chamber or proportional counters with Ar gas flowing as a carrier gas regulated by MFC (mass flow controller). To recover T in the exhaust gas, combination of CuO and water bubblers were used. The k-type thermocouples were located just under the molybdenum sample holder to measure the sample temperature directly.

To evaluate the D detection by QMS, the W sample (10 mm $^{\phi}$, 0.5 mm^{t}) exposed to plasma discharge in 2014 campaign in LHD (LHD sample), was used. The LHD sample was exposed to D_2 gas with the pressure of 90 kPa at 573 K at Shizuoka University and TDS measurement was performed with the heating rate of 0.5 K s^{-1} from room temperature up to 1173 K. The flow rate of Ar gas was set to be 13.3 sccm. After observation for D desorption by QMS, simultaneous D and T measurement was performed using the LHD sample exposed to additional DT gas (T/D = 0.05) with the pressure of 2 kPa at 573 K for 4 hours at University of Toyama. 1.0 keV D_2^+ implanted SiC samples (10 mm $^{\phi}$, 0.5 mm^{t}) were used to compare TDS spectra derived by the conventional TDS system and the present HI-TDS system.

3) Results and Discussion

The flow rate of 13.3 sccm was found to be suitable to detect both of D and T to achieve same TDS spectra shown in Fig. 2 when the DT gas exposed LHD sample was applied.

It was found that major hydrogen desorption stages consisted of two temperature regions, namely 700 K and 900 K, which was consistent with the previous hydrogen plasma campaign and most of hydrogen would be trapped by the carbon-dominated mixed-material layer. By D2+ implantation, major D desorption was found at ~900 K with a narrow peak due to energetic ion implantation. For gas exposure, H was preferentially replaced by D and T with a lower trapping energy. In addition, T replacement rate by additional H2 gas exposure was evaluated. This fact indicates that the hydrogen replacement mechanism would be clearly changed by exposure methods.

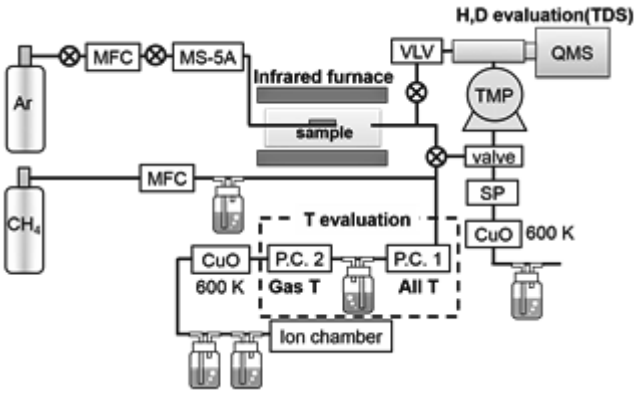

Fig. 1 the schematic flow chart of HI-TDS system.

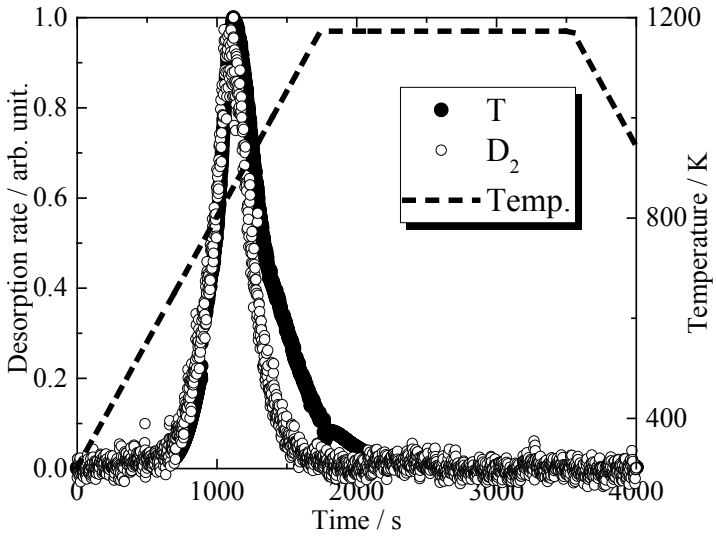

Fig. 2. Comparison of D and T TDS spectra for DT gas exposed PI samples with Ar gas flow rate of 13.3 sccm