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Development of Compact Divertor Plasma Simulator for Hot Laboratory
ホットラボ用小型ダイバータプラズマ模擬試験装置の開発

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We have newly developed a compact divertor plasma simulator, which is planning to be installed and operated in a radiation control area. The developed device, having smaller space requirement and lower electric power consumption than conventional devices, is able to generate a steady state deuterium plasma more than 10^{18} m^{-3}. The sample stage equipped with an air-cooling system makes sample temperature almost constant during plasma exposure. Further the plasma-irradiated sample can be transported to the infrared heater for Thermal Desorption Spectroscopy (TDS) analysis without air exposure.

1. Introduction

Particle control is one of the most critical issues in fusion devices. It was reported that deuterium retention in a neutron-damaged tungsten sample is dramatically increased due to particular defects induced by neutron irradiation[1]. Toward DEMO, more systematic studies of hydrogen isotope retention in neutron-damaged materials will be required. However, there are few facilities to irradiate high density plasma, relevant to edge plasma condition, to neutron-damaged samples.

In this study, we have developed a compact divertor plasma simulator (CDPS) [2] in Nagoya University, which is planning to be installed and operated in a radiation control room of International Research Center for Nuclear Materials Science of the Institute for Materials Research of Tohoku University (hereafter the "Center") [3]. The Center already has a lot of neutron irradiated samples with 3 mm in diameter and 0.1~0.2 mm in thickness including tungsten and tungsten alloy. These samples can be utilized in the CDPS for plasma-wall interaction study.

2.Compact Divertor Plasma Simulator(CDPS)

Fig. 1 shows the schematic of the CDPS. The photo of the CDPS is shown in Fig. 2.

The CDPS is equipped with two magnet coils. A dc plasma source is composed of a zigzag-shaped LaB_6 cathode and a water-cooled hollow cupper anode. In the plasma source, high density steady-state plasma can be generated by the Phillips Ionization Gauge (PIG) discharge.

A metallic sample is fixed on a sample stage equipped with an air-cooling system. A thermocouple disposed to contact with the sample detects the sample temperature. The sample temperature during plasma exposure is controlled within uncertainty of 5K by changing the airflow rate.

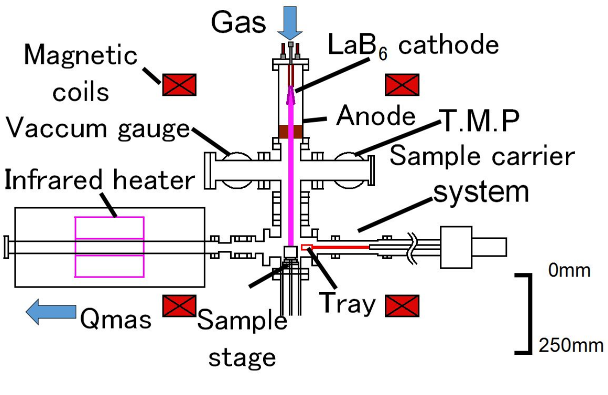

Fig. 1. A Schematic of the compact divertor plasma simulator (CDPS)

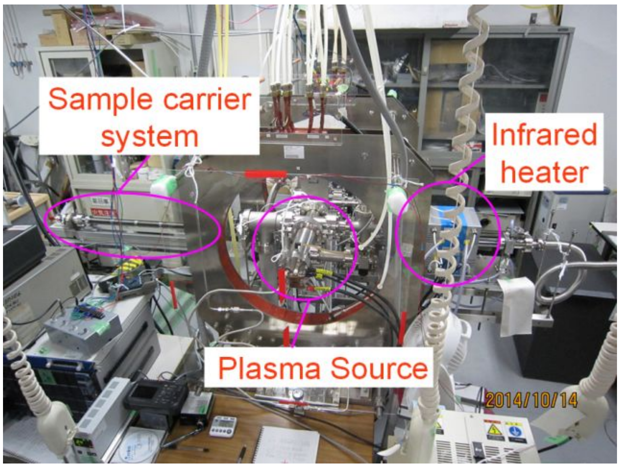

Fig. 2. A Photo of the CDPS

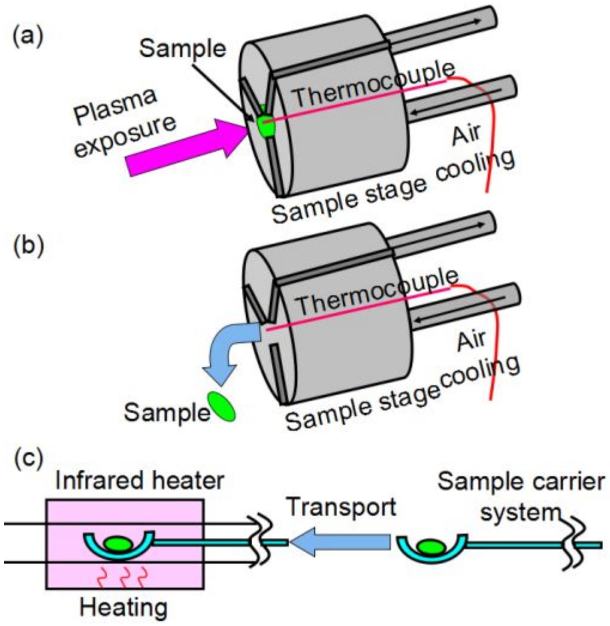

Fig. 3. Schematics illustrating the processes to transport a sample from the plasma irradiation region to the TDS measurement region.

Further, the CDPS has a sophisticated sample carrier system, which makes it possible to transport the plasma-irradiated sample on the sample stage to the infrared heater for TDS analysis without air exposure. It guarantees more precise analysis of TDS.

Fig. 3 illustrates the processes to transport the plasma-irradiated sample in vacuum. During plasma exposure, the sample is mounted on the sample stage by being hooked by the three molybdenum hooking pawls as shown in Fig. 3(a). After plasma exposure, the sample is removed by releasing the pawls (b). The dropped sample is received by a tray made of tantalum, which is mounted in the head of the sample carrier system. Finally, the sample is moved to the infrared heater of the TDS device by a motor drive (c). These processes are operated in vacuum. Therefore, the sample can be analyzed with TDS without air exposure following by plasma exposure, and the interval between the plasma exposure and TDS analysis can be minimized.

3. Plasma performance in the CDPS

The density and temperature of the produced plasmas were measured with an electrostatic probe located at 10 mm away form the sample stage. The working gas is deuterium. The applied magnetic field is 0.014 T. The plasma diameter is approximately 15 mm. Fig. 4 shows the discharge power dependences of the electron density as a parameter of deuterium gas pressure. The plasma density monotonically increases with the discharge power. On the other hand, within this experimental condition, lower gas pressure leads to higher electron density. The plasma density reaches 1.4×10^{18} m^{-3} at a discharge power of 3.5 kW with a gas pressure of 1 Pa. The electron temperature, not depending on the discharge power, was almost 8 eV.

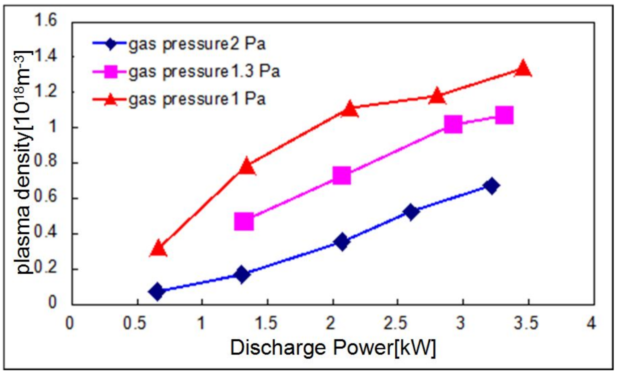

Fig. 4. Discharge power dependence of the deuterium plasma density.

Acknowledgment

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References

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