§20. Plasma Wall Interactions under Inert Gas Puffing for Reduction of Heat Flux

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In order to decrease heat flux to the divertor tiles, gas puffing using inert gas or N_2 to the divertor plasma has been conducted in fusion devices. Plasma-wall interactions in the gas puffing condition have not been clarified yet. The aims of the present study are the evaluations of erosion, surface modification and gas retention of plasma-facing wall exposed to deuterium plasma with the gas puffing using plasma exposure devices. A sample holder with gas puffing system in the vicinity of the samples for ECR plasma exposure apparatus [1] were manufactured and plasma parameters such as electron temperature with Ar gas puffing were measured in FY2013. In FY2014, the deuterium retention and desorption behaviors of 316LSS after deuterium plasma exposure with Ar puffing were evaluated. In this fiscal year, the Ar flow rate furthermore increased for the achievement of detached plasma. In addition, deuterium desorption and retention properties of polycrystalline tungsten after the plasma exposure were evaluated using the same apparatus.

The tungsten samples were mechanically polished, cleaned with ethanol, degassed in a vacuum at 1273K for 0.5hr and then exposed to the plasma. The discharge power was 200 W, the discharge pressure of deuterium gas was 8 Pa, the bias voltage to the samples was -250 V. Ar flow rate was taken in the range of 0 to 2 sccm, which corresponded to 0-0.66 for partial pressure fraction of P_{Ar}/P_{D2}. The estimated ion fluence was about 2×10^{-17} cm^{-2}. Optical emission intensities from the ions and the radicals, electron density and temperature in the vicinity of the sample were measured during the exposure. After the exposure, the deuterium desorption and retention properties of the sample were estimated by thermal desorption spectroscopy. The temperature range was RT to 1273K with a ramp rate of 0.5K s^{-1}. The surface morphologies of the samples were observed using a scanning electron microscope.

Figure 1 shows Ar flow rate dependences of D_α and ArI emission intensities. The intensities increased with the flow rate up to 1 sccm. The measured electron density also increased, so the increase of D_α was owing to the increase of electron collision. Above 1 sccm, D_α significantly decreased with the increase of the flow rate. The substantial decrease of the electron temperature was observed, which was responsible for the D_α decrease. Figure 2 shows thermal desorption spectra of D_2 for the samples exposed to deuterium plasma with or without Ar gas puffing. For the small rate cases, the 500K desorption peak decreased and then increased with the rate. In the case of 2 sccm, a new peak appeared at 400K with substantial decrease of the 500K peak. This spectrum was quite similar to that of tungsten exposed to high-energy helium ions prior to deuterium ion irradiation [2]. The amount of retained deuterium decreased in the case of the small rate. Above 0.3 sccm, the amount increased and then decreased with the flow rate. Figure 3 shows surface morphologies of samples exposed to deuterium plasma with or without Ar gas puffing. In the case of the high flow rate, the grain boundaries became clear and small pores was formed. These might be owing to selective sputtering of carbon impurities at the boundary and introduction of damages by high energy Ar irradiation. It could be reasonably explained that these compositional and structural changes caused the changes in the desorption and retention behaviors after the plasma exposure with Ar gas puffing. Further investigations with parametric change for the exposure and quantitative discussions based on the results of plasma diagnostics will be done in next fiscal year.

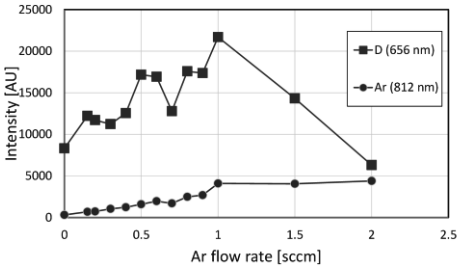

Fig. 1. Emission intensities Dα and ArI in the vicinity of tungsten samples as a function of Ar flow rate.

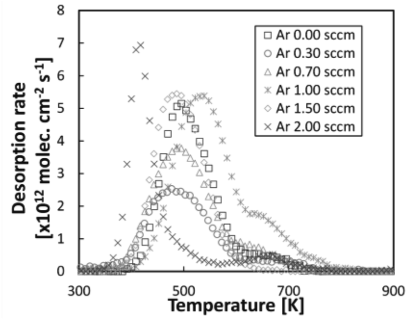

Fig. 2. Thermal desorption spectra of D_2 for tungsten samples exposed to deuterium plasma with or without Ar gas puffing.

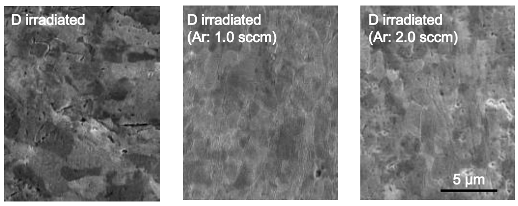

Fig. 3. Surface morphologies of tungsten samples exposed to deuterium plasma with and without Ar gas puffing.

1) Yanagihara, H. et al.: J. Nucl. Mater. **241-243** (1997) 1098.
2) Hino, T. et al.: Fusion Eng. Des., **39-40** (1998), 227.