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

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In order to decrease heat flux to divertor tiles, gas puffing using inert gas or nitrogen to the divertor plasma has been conducted in fusion devices. Plasma-wall interactions in 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 were manufactured in FY2013. Using the sample holder, the samples made of 316L stainless steel were exposed to deuterium plasma with Ar gas puffing in ECR plasma exposure apparatus[1]. Before the exposure, the samples were mechanically polished, cleaned with ethanol and degassed in a vacuum at 1273K for 1hr. The discharge power was 200 W, the discharge pressure of deuterium gas was 8 Pa, the bias voltage to the samples was -250 V and the plasma-exposure time was 1 hr. The Ar gas flow rate was taken in the range of 0 to 0.4 sccm. The ion fluence estimated from the sample current density during the exposure was almost the same, when the Ar gas flow rate was changed. Optical emission intensities from the ions and the radicals in the vicinity of the sample were measured using an optical spectroscope. Electron density and temperature near the sample were estimated using a Langmuir probe. After the plasma exposure, the gas desorption and retention properties of the sample were estimated by thermal desorption spectroscopy. The sample was linearly heated up to 1273K with a ramp rate of 0.5 K s-1. During the heating, the desorbed gas was quantitatively measured. The surface morphologies of the exposed samples were observed using a scanning electron microscope.

Figure 1 shows electron density and temperature in the vicinity of the sample as a function of Ar flow rate. The temperature decreased and the density increased with the Ar flow rate above 0.1 sccm. The increase of electron density resulted from ionization of introduced argon gas. We will evaluate electron density and temperature in the case of larger Ar flow rate. Figure 2 shows thermal desorption spectra of D_2 for the samples exposed to deuterium plasma with or without Ar gas puffing. The spectrum of larger flow rate case had a large peak at around 480-580 K, which was owing to deuterium desorption trapped at grain boundaries and radiation damages [2]. The amount of retained deuterium drastically increased in the case of the Ar gas flow rate above 0.3 sccm. Figure 3 shows surface morphologies of 316LSS samples exposed to deuterium plasma with or without Ar gas puffing. The grain size at the top surface of Ar gas puffing case was larger than that without Ar puffing case. This increase in the size might be owing to localized energy deposition at the top surface, which could lead to recrystallization. The localized energy deposition at the top surface could also result in the enhancement of inward deuterium diffusion, which cause the increase in the deuterium retention. Further investigations are necessary for detail discussion.

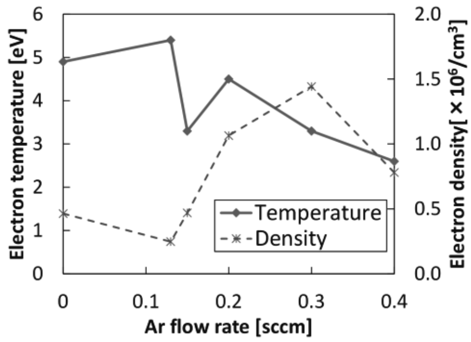

Fig. 1. Electron temperature and density in the vicinity of sample as a function of Ar flow rate.

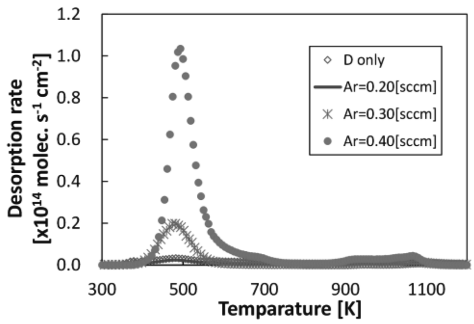

Fig. 2. Thermal desorption spectra of D_2 for 316LSS samples exposed to deuterium plasma with or without Ar gas puffing.

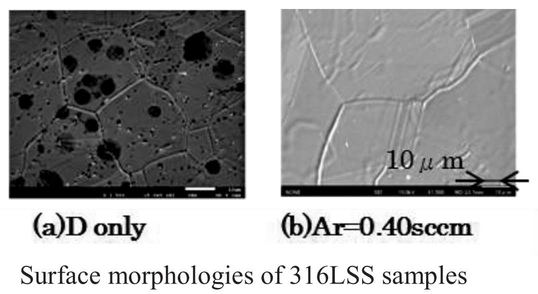

Fig. 3. Surface morphologies of 316LSS samples exposed to deuterium plasma without Ar gas puffing, (a), and with Ar gas puffing.

1) Yanagihara, H. et al.: J. Nucl. Mater. **241-243** (1997) 1098.
2) Wilson, K.L et al.: J. Nucl. Mater. **76&77** (1978), 291.