Deuterium concentration of co-deposited carbon layer by deuterium arc discharge

重水素アーク放電で作成した同時堆積炭素膜の重水素濃度

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Tritium retention of a carbon film deposited on the gap side surface of plasma facing materials is a primary issue for fusion reactor because carbon layer in the gap is hardly to remove. In this study, deuterium concentration and retention profile in a gap were investigated for carbon films prepared by using deuterium arc discharge with carbon electrodes. Deuterium retained in the carbon layer desorbed mainly in the form of D_2, HD, CD_4 and C_2D_4. The amount of deposited carbon and retained deuterium in the gap decreased exponentially with the increase of the depth and more rapidly decreased with decreasing gap width. The atomic ratios of D/C of the carbon had almost no dependence on the distance from gap entrance and slightly increased with increase in the gap width.

1. Introduction

Carbon material has been widely used as plasma-facing materials in present fusion devices and is a candidate for the divertor target plate of ITER. Divertor target is exposed to high particle flux and heat load, and eroded. The sputtered carbon atom is re-deposited in vacuum vessel incorporating fuel hydrogen. Therefore, it is important to investigate the hydrogen retention on co-deposited carbon layer. In particular, the tritium retention in the side surface of gaps between plasma-facing tiles is important because carbon films in the gap could retain a lot of fuel hydrogen and it is difficult to remove [1]. In this study, we investigated the deuterium concentration of co-deposited carbon layer in gap prepared by deuterium arc discharge with carbon electrodes.

2. Experimental

Co-deposited carbon layers used in this study were prepared using a D_2 arc discharge. Fig.1 shows schematic diagram of arc discharge device. The sample stage had a gap with a depth of 100 mm, and 10 molybdenum substrates (52×6×0.05 mm) were set on the side surface of the gap. During the arc discharge, the carbon electrode was heated up and sublimation of carbon occurred.

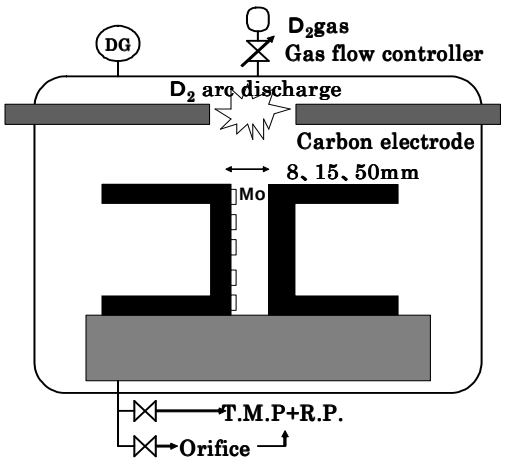

Fig.1 Schematic diagram of arc discharge device.

The emitted carbon atoms deposited on Mo substrates in the gap incorporating deuterium atoms. The voltage and current of the discharge were 10-20 V and 50 A, respectively. Discharge pressure was kept at 5-10 Pa and Substrate temp was: 673K. The distances of the gap were varied from 8 to 50 mm. After the arc discharge, the carbon layers deposited on Mo substrate were analyzed. The amount of deposited carbon was estimated from weight gain of the substrates after the discharge by a microbalance. The amount of retained deuterium in the carbon

layer was measured with thermal desorption spectroscopy (TDS). Based on the measurements, the deuterium concentration in the carbon layer was estimated.

3. Results and discussion

Deuterium retained in the carbon layer desorbed mainly in the form of D_2, HD, CD_4 and C_2D_4. Fig.2 shows typical thermal desorption spectra of D-containing molecule for the carbon layer prepared with at gap width of 50 mm. The D_2 and CD_4 desorption rate had a main peak around 1100 K and 750 K, respectively. These desorption spectra are similar to those of the isotropic graphite irradiated energetic deuterium ions [2].

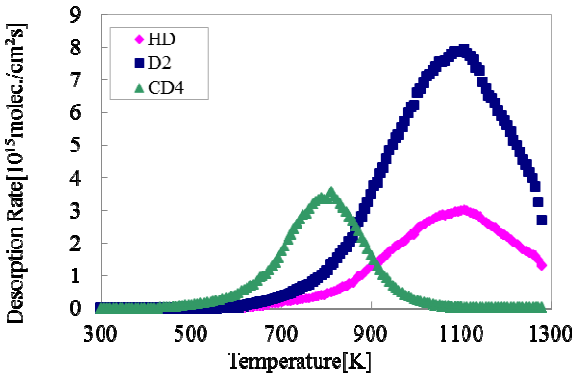

Fig.2 Thermal desorption spectra of D_2, HD and CD_4 for the carbon layer prepared at 50mm gap.

Fig.3 shows deuterium retention and weight gain of Mo substrate as a function of distance from gap entrance. The amount of carbon deposition and deuterium retention decreased exponentially with increase of the gap depth, and decayed more rapidly with decreasing gap width.

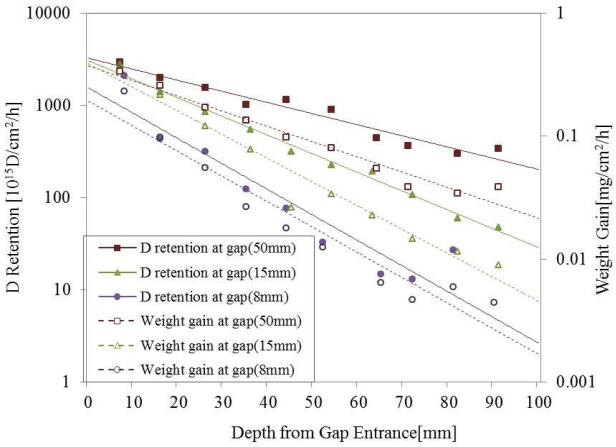

Fig.3 Deuterium retention and Weight gain of Mo substrate vs distance from gap entrance.

Fig.4 shows deuterium concentration of carbon films against distance from gap entrance. The deuterium concentration (D/C) had almost no dependence on the gap depth. The deuterium concentration tended to increase with increase in the gap width. The D/C for the gap width of 8, 15 and 50 mm were 0.15 - 0.25, 0.10 - 0.25 and 0.05 - 0.17, respectively.

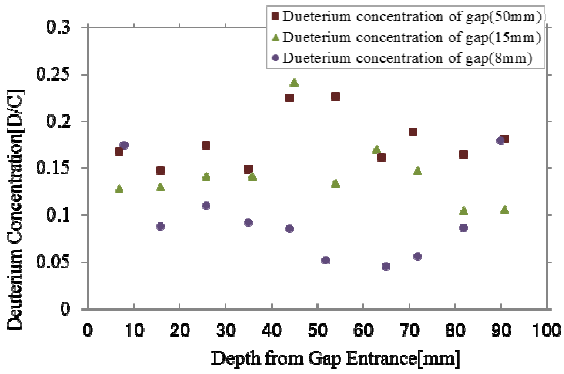

Fig.4 Dueterium concentraition of carbon films vs distnce from gap entrance.

4. References

[1] T. Hino et al, Fusion Engineering and Design, 61-62 (2002) 605-609

[2] Y. Yamauchi et al., J. Nucl. Mater. 241–243 (1997) 1016–1021.