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Hydrogen and helium desorptions from B_4C overlaid graphite and isotropic graphite

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Abstract

The desorption behavior for hydrogens and heliums trapped in B_4C overlaid graphite and isotropic graphite were examined by using a technique of thermal desorption spectroscopy. For the B_4C overlaid graphite, the trapped helium desorbed at relatively low temperature, ~300 °C, which was much lower than that of the hydrogen(~800 °C). For the graphite, the similar behavior was obsearved. The present data are useful to understand the uptake of the helium or the fuel hydrogen in a burning plasma.

1. Introduction

As the plasma facing material in fusion devices, B_4C coated graphite called B_4C overlaid graphite and boron film coatings on the graphite wall have been employed to improve recycling characteristics(1-3), to trap or getter the oxygen impurity(4,5) and to reduce the chemical sputterings of the graphite(6). Since the hydrogen trapped in the boron desorbs at relatively low temperature, ~350 °C, and the impact desorption cross section is larger than that of the carbon, the hydrogen concentration of the boron can be kept small by the baking and/or the helium discharge cleanings.

In JT-60U, a large number of the B_4C overlaid graphite tiles have been used in the divertor(7), in addition to the boronization pretreatment before the main discharge shots. When the heat flux to the B_4C tiles in the divertor was enhanced by shifting the poloidal position of the divertor trace, it was observed that the level of helium ions injected as helium neutral beams was largely reduced(7). It is presumed that the evaporated borons and/or the carbons getter or trap the heliums. However, the data concerning a helium trapping of boron material has not been systematically obtained yet. It thus is important to examine the helium trapping behavior of boron or carbon material.

In the present study, first the B_4C overlaid graphite was exposed to hydrogen ion beam until the hydrogen concentration saturated. Then, this material was exposed(8) to helium

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ion beam and the desorption spectra for both hydrogens and heliums are taken by using a technique of thermal desorption spectroscopy, TDS. The obtained spectra showed that the peak temperature of helium desorption was significantly lower than that of the hydrogen. Similar results were obtained also for the isotropic graphite. The present data may be helpful to understand the uptake behavior of the helium for the B_4C overlaid graphite or the isotropic graphite.

2. Experiments

The B_4C overlaid graphite and the isotropic graphite, PD-330S, made by Hitachi Chemical Inc., were irradiated at RT by hydrogen ions with an energy of 1.5 keV in the ECR ion source[6]. The fluence of hydrogen ions was large enough for the hydrogen concentration to be saturated, e.g. $\sim 5 \times 10^{18}$ H/cm^2. Then, these materials were irradiated by the helium ions with a fluence up to 3×10^{19} He/cm^2 and an energy of 4.5 keV in the same apparatus. After the irradiation due to the helium ions, the trapped amounts of both the hydrogen and the helium were measured by a TDS technique. For this purpose, the irradiated samples were resistively heated with a ramp rate of 50 °C/min and the desorption amounts were quantitatively measured by a quadruple mass spectrometer, QMS, in the same apparatus.

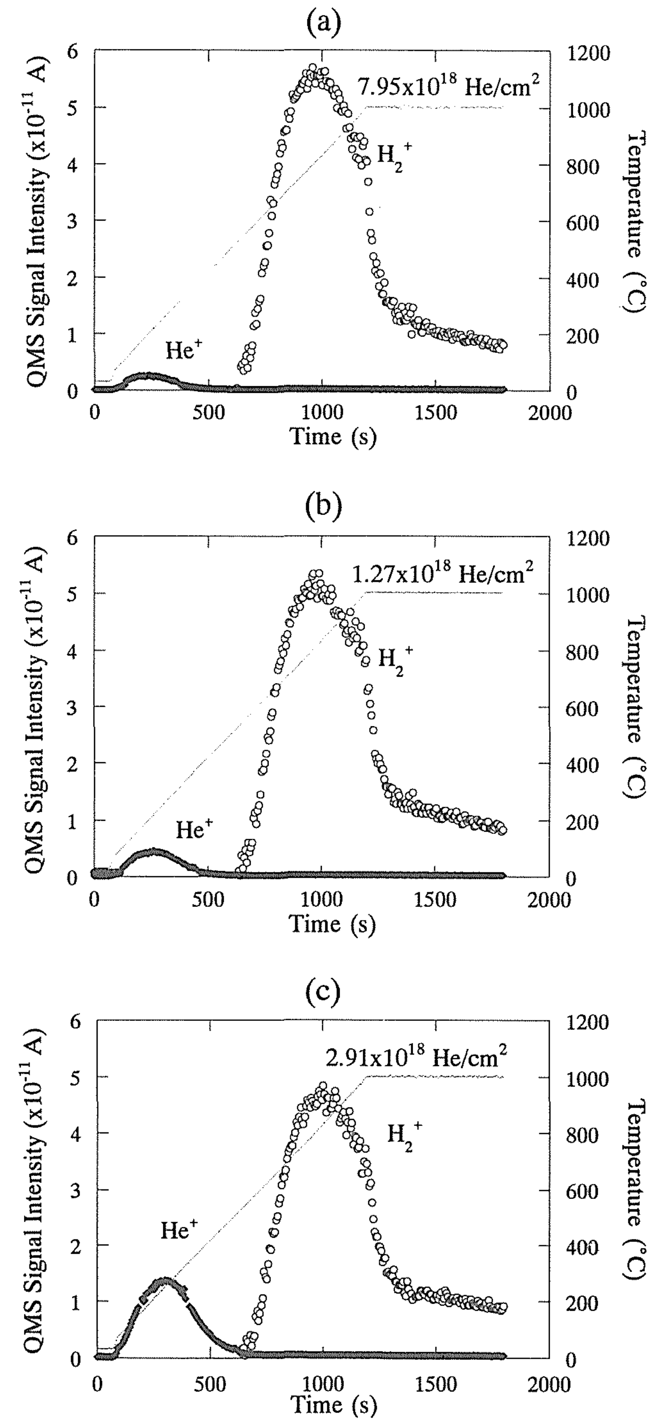
Figures 1(a), (b) and (c) show the desorption spectra of the isotropic graphite for different values of the helium fluence. As the increase of the helium fluence, the trapped amount of helium increased and the peak temperature (~200 °C) was very much lower than that of the hydrogen (~800 °C). The selective pumping of the graphite for the helium becomes possible when the temperature is lower than approximately 500 °C.

Figures 2(a), (b) and (c) show the desorption spectra of the B_4C overlaid graphite for different values of the helium fluence. Compared with the case of the graphite, the desorption peak of the helium was relatively broad but the helium desorption took place at the temperature lower than that of the hydrogen. Again the selective pumping of the B_4C overlaid graphite becomes possible when the temperature is lower than approximately 300 °C.

Figures 3 and 4 show the total desorption amounts of H_2 and He for the graphite and the B_4C overlaid graphite, respectively. Although the hydrogen amount retained decreased with an increase of the helium fluence, the helium amount trapped increased with the helium fluence. The capability of the B_4C overlaid graphite for the helium trapping is roughly the same as the graphite.

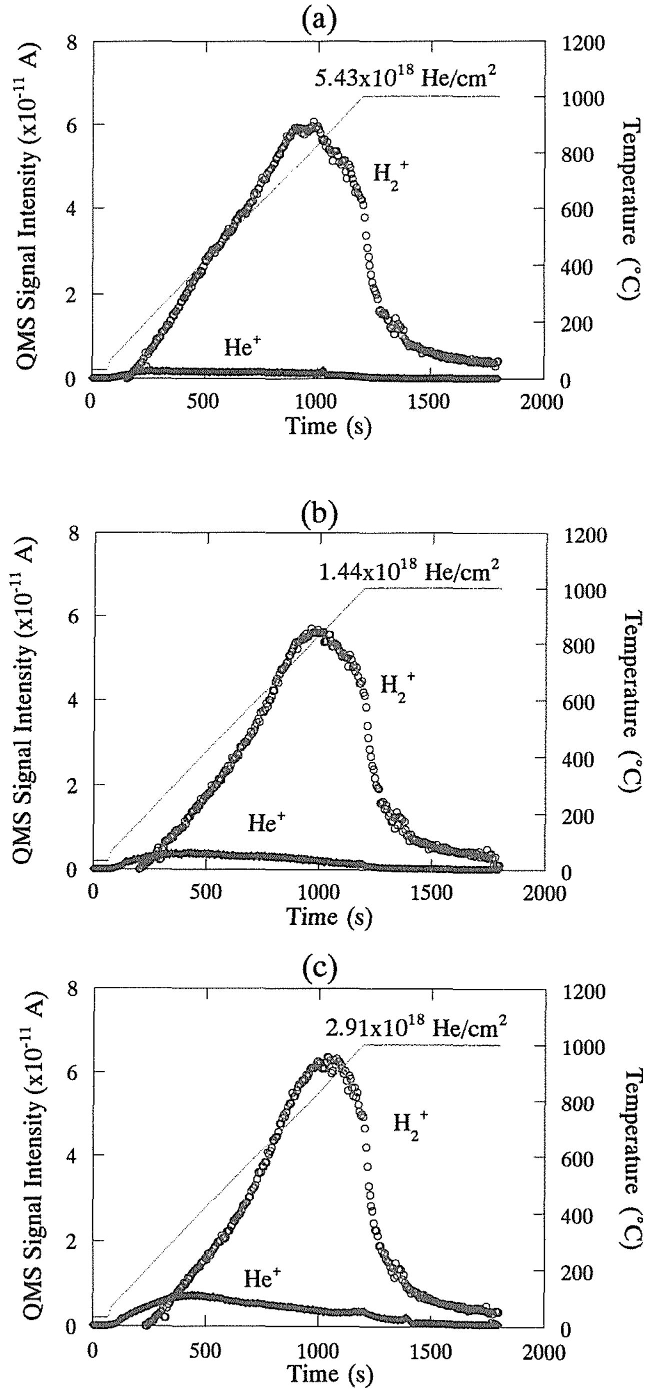
3. Discussions

The present data suggest that the helium can be trapped both by the boron or the carbon if the wall temperature is lower than approximately 500 °C. When the B_4C overlaid graphite receives a large heat flux, both the boron and the carbon can evaporate and then the selective



Figures 1 (a),(b)and(c)

H_2 and He desorption spectra of isotropic graphite after He ion irradiations with He fluences of 7.95×10^{17}He/cm^2(a), 1.27×10^{18}He/cm^2(b)and 2.91×10^{18}He/cm^2(c).



Figures 2 (a),(b)and(c)

H_2 and He desorption spectra of B_4C overlaid graphite after He ion irradiations with He fluences of 5.43×10^{17}He/cm^2(a), 1.44×10^{18}He/cm^2(b)and 2.91×10^{18}He/cm^2(c).

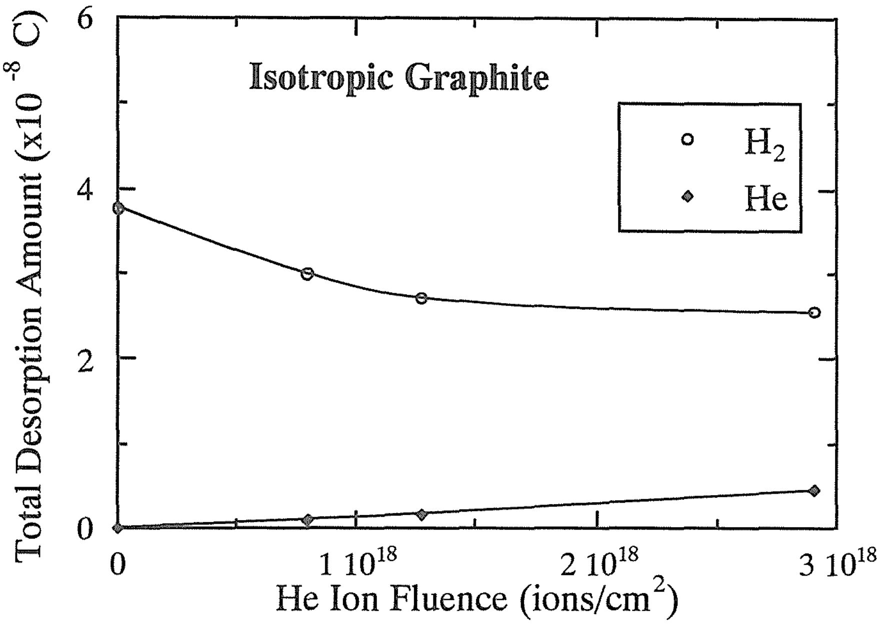


Figure 3

He fluence dependences of total trapped amounts of H_2 and He for isotropic graphite.

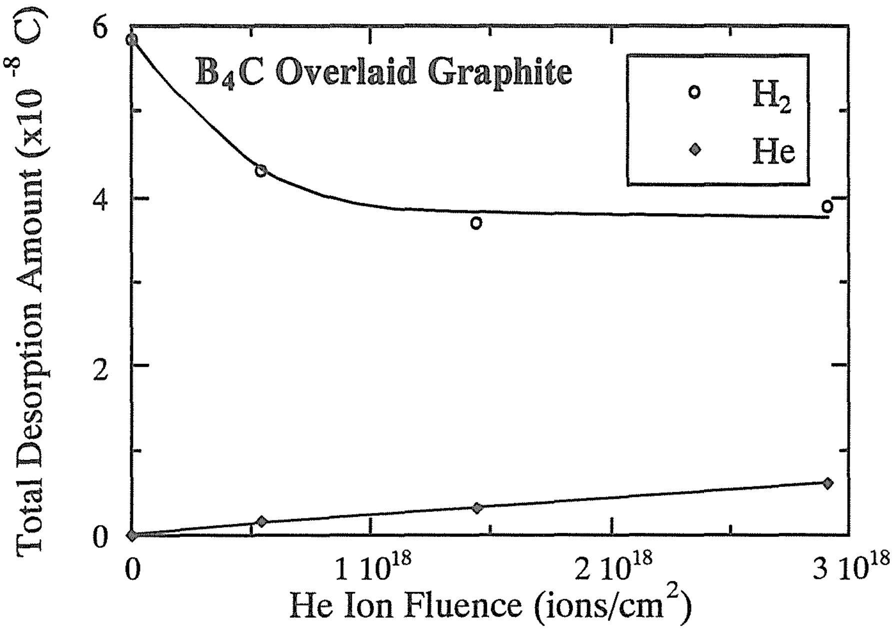


Figure 4

He fluence dependences of total trapped amounts of H_2 and He for B_4 C overlaid graphite.

pumping for the helium may take place if the wall temperature is not so high. The strong uptake of the helium due to the evaporation of the B_4C overlaid graphite may be able to be explained by this reason. In addition, the present data may be helpful to understand the helium uptake in a burning plasma.

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