§93. Tritium Desorption and Tritium Removal from Tungsten Pre-irradiated with Helium

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In plasma-facing materials, how much of the retained tritium is released during long period of time at elevated temperatures after tritium irradiation is important in terms of tritium removal by baking in fusion devices. Measurement of tritium retention, such as using an imaging plate technique, is a non-destructive analysis, which allows tritium retention measurements to be performed repeatedly. Using these advantages in tritium detection, in this study, tritium ion irradiation experiments were performed for helium pre-irradiated tungsten and the tritium release behavior at elevated temperatures were investigated.

Samples used in this study were 99.9% pure polycrystalline tungsten (Nilaco co.) Before tritium irradiation, helium ions with an energy of 5 keV were bombarded onto samples using an ECR ion source at Hokkaido University. The helium ion flux were estimated by measuring the sample current to be ~2×10^{13} He/cm^2/s, and the helium ion fluence 1×10^{17} He/cm^2 and 1×10^{18} He/cm^2. The sample was at room temperature during the helium irradiation. Afterwards, tritium ion irradiation was performed at the University of Toyama. In this irradiation, tritium-containing gas is released by heating a tritium source containing deuterium (99.5 %) and tritium (0.5 %). Since the fraction of tritium contained in the tritium source is much smaller than deuterium, the primary tritium-containing molecule released is considered to be the DT molecule. DT^+ ion was implanted into samples with a DT^+ ion energy of 1.0 keV (0.6 keV for sole T). The ion fluence estimated by measuring the sample current was 4.5 x 10^{14} T/cm^2 (9.0 x 10^{16} D+T/cm^2) and the ion irradiation lasted approximately 30 min. The sample was at room temperature during the irradiation. Some of tritium irradiated samples were preserved in a desiccator pumped by a rotary pump for about 300 days at room temperature. In order to investigate tritium reduction during baking, isochronal annealing at temperatures ranging from 423 K to 873 K in vacuum was also performed on tungsten samples just after tritium irradiation and after long-term (~300 days) preservation in vacuum.

Figure 1 shows the decrease in tritium retention during isochronal annealing (baking) of tungsten samples just after tritium irradiation and also after approximately 300 days preservation in vacuum. In this figure, the tritium retention is normalized against that just before baking. The decrease during isochronal annealing was considerably influenced by helium irradiation. In the case of tungsten just after tritium irradiation, the reduction of tritium retention at a helium fluence of 1x10^{17} He/cm^2 was seen to be smaller than in the un-irradiated case. This is possibly owing to the strong trapping of tritium at 1x10^{17} He/cm^2. In the case of a helium fluence of 1x10^{18} He/cm^2, tritium retention dropped more sharply than the 1x10^{17} He/cm^2 case. Rapid tritium release caused by formation of surface-connected open pores [1)-4)] would be a possible reason for the large reduction of tritium retention at 1x10^{18} He/cm^2. The tritium reduction in tungsten after ~300 days of being preserved in vacuum was smaller than that just after tritium irradiation. A weekly trapped tritium could be preferentially released in the early period of vacuum preservation and strongly trapped tritium would remain in tungsten for long time. This would be a reason for the smaller reduction of tritium during isochronal annealing. This result suggests that tritium retained for long periods in helium irradiated tungsten would be hardly removed at lower baking temperatures in fusion devices.

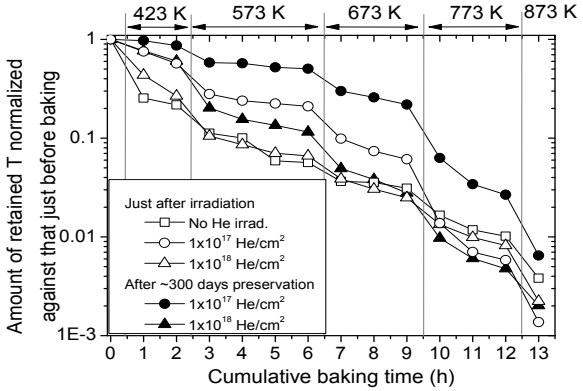

Figure 1 Reduction of tritium retention during isochronal annealing (baking) for tungsten samples just after tritium irradiation and after approximately 300 days preservation in vacuum.

1) Lifshitz, Y. et al.: J. Nucl. Mater., **137** (1986) 139.
2) J. H. Evans.: J. Nucl. Mater., **76 & 77** (1978) 228.
3) Jager, W. et al.: J. Nucl. Mater., **93 & 94** (1980) 756.
4) Miyamoto, M. et al.: J. Nucl. Mater., 415 (2011) S657.