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タングステンにおける照射損傷形成プロセスの重水素捕捉への影響
Effects for Formation Processes of Irradiation Damage on Deuterium Trapping in Tungsten

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Tungsten is a candidate material for plasma facing material of fusion reactors. Irradiation damages such as dislocation loops, vacancies and voids will be introduced in tungsten by the fast neutron and the alpha particles during plasma operation. Tritium will be stably trapped by these irradiation damages in tungsten, resulting in the increase of tritium inventory in plasma facing materials. In actual condition, irradiation damages will be formed in tungsten via several displacement processes by collision particles with various masses and energies. Especially, the cascade collision processes will produce a number of irradiation damages in narrow region of tungsten, indicating the formation of voids as well as vacancies and dislocation loops. For the estimation of tritium inventory, tritium trapping processes in these irradiation damages should be evaluated. In the present study, lower energy light ions or higher energy heavy ion irradiations were carried out into tungsten to induce different displacement processes of tungsten atoms in order to produce different types of damages in tungsten. The deuterium was injected into damaged tungsten by means of ion implantation. The deuterium trapping behavior was evaluated by Thermal Desorption Spectroscopy (TDS).

Several ion species (C^+, He^+, Fe^{2+}) were pre-irradiated at R.T to introduce irradiation damages into tungsten samples. The energies of C^+, He^+ and Fe^{2+} were 10 keV C^+, 3 keV He^+ and 2.8 MeV Fe^{2+}, respectively. The D_3^+ implantation was performed at 473 K using TRIIX (Tritium Ion Implantation Experiment) at INL. The D^+ fluence was set to be 3.2 x 10^{23} D^+ m^{-2}. Thereafter, TDS experiments were also carried out with the heating rate of 10 K /min up to 1173 K.

The deuterium desorption stage was found at 520 K (Peak A) for C^+ or He^+ irradiated samples although that desorption stage was not clearly observed for the non-damaged tungsten as shown in figure, considering that Peak A was attributed to the desorption of deuterium trapped by ion-irradiation induced vacancy. In addition, Peak B (620 K), which was the dominant deuterium desorption for non-irradiated tungsten, was disappeared. It was considered that the preferential trapping of deuterium by vacancies near surface region would refrain deuterium trappings as Peak B, indicating that Peak B was originated from deuterium retained by intrinsic trapping sites such as dislocation loops, intrinsic cavities and/or oxygen impurities in bulk region. The major deuterium desorption stage for Fe^{2+} irradiated sample was found at the temperature above 800 K. The deuterium desorption in higher temperature above 700 K was assigned to the desorption of deuterium chemisorbed on the inner surface of voids induced by cascade collisions by 2.8 MeV Fe^{2+} irradiation. Because of the higher energy transfer rate of 2.8 MeV Fe^{2+} to tungsten atoms, cascade collisions would easily occurred, proceeding the formation of voids in tungsten. These cascade collision processes would take place under the 14 MeV neutron irradiation circumstance. A precise understanding of cascade collisions in tungsten by 14 MeV neutron irradiation should be required to estimate tritium inventory.

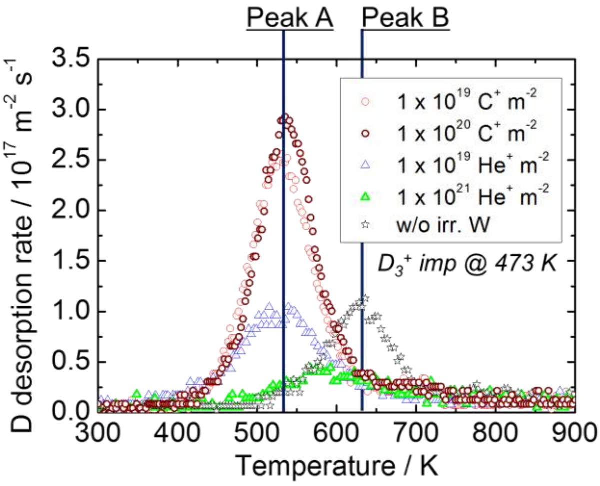

Fig. D TDS spectra of damaged tungsten samples