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Discussion of hydrogen isotope retention in radiation-damaged tungsten
照射損傷タングステンの水素同位体吸蔵に関する考察

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Hydrogen isotope retention in radiation-damaged tungsten is one of the most important issues for a fusion reactor. Microstructure and hydrogen isotope retention in re-crystallized tungsten samples with Cu^{2+} irradiation will be discussed.

Hydrogen isotope retention in the plasma facing materials (PFCs) is a crucial issue of safety as well as particle control for a future fusion device. Tungsten is a first candidate of the PFC because of high melting temperature, low sputtering yield and low hydrogen isotope retention. Recent researches indicate that surface modification such as redeposition and helium bubble formation, however, gives a significant effect on the retention properties of tungsten. Besides, damage by fusion neutrons must increase retention in tungsten. In this case, trapping sites of hydrogen are created in not only the surface but also whole bulk region, indicating that the amount of hydrogen isotope retention becomes rather large. It is important to understand mechanism of hydrogen isotope retention by the neutron damage from the microscopic viewpoint and develop a method of reduction of the retention. The main objectives of this study is to understand the effect of neutron and surrogate irradiation upon microstructure of tungsten and through that the effect of the damage of tungsten on hydrogen isotope retention by using charged particle beams (H, D, He, Cu and W), transmission electron microscopy (TEM) and thermal desorption spectroscopy (TDS) after divertor-like plasma exposure.

In this study, tungsten is irradiated by Cu^{2+} with the energy of 2.4 MeV. Figure 1 shows the damage depth distribution in an irradiated tungsten sample and depth dependence of the concentration of the injected Cu atoms (apa). The SRIM code calculation with displacement energy of 55 eV indicates that the peak damage region is 400 nm and the displacement damage distribution is up to 600 nm. Two samples of re-crystallized tungsten with Cu^{2+} irradiation (2 dpa) at room temperature and 500 K have been prepared and will be measured hydrogen isotope retention with TDS after deuterium plasma exposure in the PWI simulator APSEDAS. In another experiment [1], an irradiated sample was thinned by using a twin-jet sample preparation technique and then heavy-ion-induced defects were observed with a transmission electron microscope (TEM). Figure 2 shows microstructural evolution of re-crystallized pure tungsten during 2.4 MeV Cu^{2+} irradiation at room temperature. This result indicates that most of the dislocation loops are nucleated by cascade collisions and additional loops are formed in the vicinity of pre-existing dislocation dislocation loops and dislocations while each loop cannot grow larger individually.

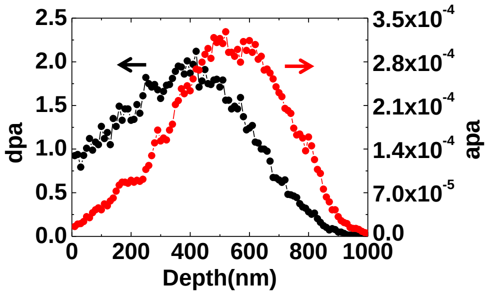

Fig.1 Estimated depth profile of displacement damage and implanted ion range distribution in tungsten calculated using the SRIM code.

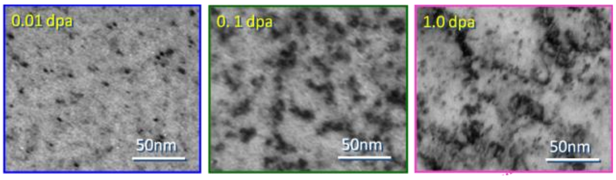

Fig.2 Microstructural evolution of re-crystallized pure tungsten during 2.4 MeV Cu^{2+} irradiation at room temperature [1].

Acknowledgments

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Reference

[1] H. Watanabe, N. Futagami, S. Naitou, N. Yoshida: J. Nucl. Mater. **455** (2014) 51.