§74. The Effects of Irradiation Damage and Transmutation Element on Irradiation Behavior of Tungsten Alloys as Plasma Facing Component

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Many researches were carried out about the surface damage due to hydrogen isotopes and He-ion irradiation, hydrogen retention property and heat load response of Tungsten (W) to study the plasma facing component behavior in fusion reactor. The plasma facing component will be exposed to high heat flux, high density flux of hydrogen and He-ion and neutron simultaneously, but unirradiated specimens had been used in these researches due to the difficulties of handling of radioactive specimens. However, it is reported that irradiation defect and their clusters behave as a trapping site of hydrogen, and the hydrogen retention behavior is influenced by the neutron irradiation conditions. It is also well known that transmutation elements by neutron irradiation would produce precipitates and affects functional performance such as thermal conductivity. Therefore, it is recognized that the material performance of plasma facing material should be studied using neutron irradiated samples.

On the other hand, the neutron irradiation research of W is very little due to the limitation of high temperature irradiation apparatus and its radioactivity. We have been studying the neutron irradiation effects on mechanical properties and microstructure of W using JMTR, JOYO and HFIR. The objective of this collaboration research is to clarify the hydrogen retention behavior of W related to the microstructure change due to neutron irradiation. In order to study the hydrogen behavior, we proposed thermal desorption spectrometry(TDS) experiment using neutron irradiated specimen at the international research center for nuclear materials science of the institute for materials research (IMR), Tohoku University. In this year, focus on the hydrogen retention experiment for HFIR irradiated specimen, which were obtained by TITAN project, characterization of the HFIR irradiated specimen compared to specimens irradiated by other irradiation field were performed.

The specimens used in this study were already neutron irradiated by JOYO, JMTR and HFIR. In the case of HFIR irradiated W, transmutation is significant because HFIR has high flux thermal neutron, but highly damaged specimen can be also obtained by HFIR. Comparing HFIR irradiated data to JOYO data, transmutation effects could be clarified. The specimens added the major transmutation elements of W such as rhenium (Re) and osmium (Os) were fabricated by arc melting and powder metallurgical process. Neutron irradiation was performed in JMTR, JOYO and HFIR. The irradiation temperature and dose ranges were 400-800^{o}C and 0.1-1.5dpa, respectively. The post irradiation experiments were carried out at the international research center for nuclear materials science of the institute for materials research (IMR), Tohoku Univ.

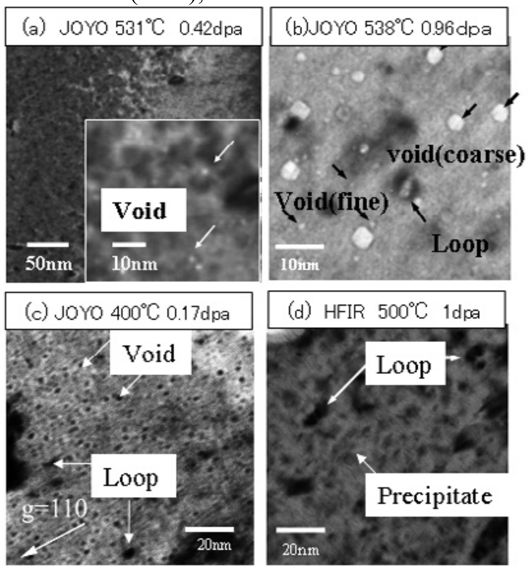

Fig. 1 The microstructure of neutron irradiated Pure W

Microstructure observations were carried out with transmission electron microscope (TEM) and characterized the defects. Furthermore, electrical resistivity which could convert to the thermal conductivity was also measured.

Figure 1 shows the microstructures of pure W irradiated at the range of 400-500oC. In fig. 1, (a), (b) and (d) are stress relived heat treated specimens before irradiation, and (c) is fabricated by arc melting. In the case of this irradiation damage level, the major damage structure of pure W was void and dislocation loop irradiated in JOYO. The microstructures were almost the same in the case of the stress relived and arc melted specimens. In HFIR irradiated pure W specimen, voids were not observed, and the dislocation loops and fine precipitates considered as the χ phase were observed. In HFIR, it is predicted that the 9% Re will produce after 1dpa irradiation due to its high thermal neutron flux. In our previous research about the W-Re alloys neutron irradiated in JOYO, the major damage structure of the W-Re alloys added the 3-5% Re were dislocation loop and irradiation induced precipitate, and the voids were not observed. Thus, in HFIR irradiated specimen, the formation of voids was suppressed by the Re induced by transmutation. For the hydrogen retention in irradiated specimen, it is considered that the hydrogen would be captured by void, and the interface and precipitate. Therefore, in order to clarify mechanism of the hydrogen retention of HFIR irradiated specimens, it is important to compare with the data of irradiated specimens in HFIR and JOYO.