Nuclear Materials Engineering   Prof. Hideki Matsui

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【Research Activities】

Efforts in this period are focused on microstructural development in vanadium alloys as candidate fusion reactor materials caused by irradiation. HVEM in situ observation on the interaction of dislocations with ultra-fine obstacles and MD simulation on this process and TEM contrast calculation based on the atomic position derived from MD are also important topics in this period, but the results have not yet been published in this time period.

Mechanical properties of vanadium alloys are strongly influenced by interstitial impurities. Control of interstitial impurities is very important since microstructural development by irradiation is affected by interstitial impurities in a more complex fashion. In our group, we have established a method to produce vanadium alloys with very low impurity contents, e.g. oxygen and nitrogen by adopting solid-state purification method with Zr foil. In a fusion reactor blanket concept, vanadium alloys are usually used with liquid lithium as coolant/breeder. During reactor operation, oxygen is transferred to vanadium. High temperature strength of vanadium alloys is considered largely caused by interstitial impurities. The paper (**Ref.*1***) describes the high temperature strength of high purity alloy. It is shown there that high temperature strength is substantially reduced by purification but that this reduction could be partially compensated for by adding e.g. chromium. Dislocation channel formation, usually observed in vanadium alloys after irradiation at a relatively low temperature is a major cause of ductility loss by irradiation. Detailed observation of channel formation is reported in the paper (**Ref.*2***). Temperature change during irradiation may often result in unpredictable effects in microstructure. In the paper (**Ref.*3***), a very coarse microstructure that appears after an upward temperature change is reported along with its possible explanation.

It is important to establish a correlation between fission and fusion neutron irradiation effects quantitatively, and the paper (**Ref.*4***) describes such a study including irradiation using Kyoto University Reactor. The paper (**Ref.*5***) is on the embrittlement of LWR pressure vessel steel.

In summary, those works published in this year are mainly on the rather fundamental effects of high purification and radiation-induced microstructural evolution. In the remaining term of mine, I would publish a rather comprehensive paper summarizing these outcomes.

1. Effects of purity on high temperature mechanical properties of vanadium alloys.
Journal of Nuclear Materials, 329-333, (2004), 442-446
M. Koyama, K. Fukumoto, H. Matsui

2. Dislocation channel formation process in V-Cr-Ti alloys irradiated below 300 ℃.
Journal of Nuclear Materials, 329-333, (2004), 467-471
M. Sugiyama, K. Fukumoto, H. Matsui

3. Varying temperature effects on mechanical properties of vanadium alloys during neutron irradiation.
Journal of Nuclear Materials, 329-333, (2004), 472-476
K. Fukumoto, H. Matsui, T. Muroga, S.J. Zinkle, D.T. Hoelzer, L.L. Snead

4. Cascade and subcascade structure in fission neutron irradiated fcc metals and their correlation to fusion neutron irradiation.
Journal of Nuclear Materials, 329-333, (2004), 1185-1189
Y. Satoh, M. Tsukada, H. Matsui, T. Yoshiie

5. Factors Controlling Irradiation Hardening of Iron-Copper Model Alloy.
Mater. Trans., Vol.45 (No.2), (2004), 338-341
Takeshi Kudo, Ryuta Kasada, Akihiko Kimura, Kazuhiro Hono, Kouji Fukuya, Hideki Matsui

【Plan】

Research plan in the next year can be categorized into three. The first one is on the interaction of dislocations with fine obstacles utilizing in situ TEM experiments, internal friction and ultrasonic attenuation. This subject is important since this is common to many of materials science subjects. The ultimate goal of this study is to establish a methodology for evaluation of macroscopic mechanical properties from microstructural information by comparing experiments and computer simulation study.

The second subject is on the mechanism of microstructural evolution under irradiation, swelling in particular. The “Giant swelling” observed in undersize type vanadium alloys has still several unresolved issues in its mechanism and will be examined in the next year. The third subject area is on the behavior of helium in vanadium alloys. THDS is a very powerful tool for this study while no other lab in the world than our group has such an apparatus. Computer simulation combined with THDS will be utilized to clarify this subject.