The Effects of Transmutation Elements on Neutron Irradiation Hardening of Tungsten

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Plasma facing materials of fusion reactor must have superior properties; high melting point, high thermal conductivity, high sputtering resistance and so on. Tungsten (W) is superior in these properties, thus it is the candidate material for divertor plate. During fusion reactor operation, not only irradiation damages but also transmutation elements such as Rhenium (Re) and Osmium (Os) are induced due to neutron irradiation. Thus, as the neutron fluence increases, the original pure tungsten changes to W-Re or W-Re-Os alloys. Consequently, it is expected that the mechanical and physical properties change gradually by the composition change. So the aim of this work is to study the effects of transmutation elements of tungsten to irradiation hardening and microstructure changes.

To simulate the effects of transmutation elements, tungsten base model alloys which include the elements shown above, were used in this study. The alloy ingots were fabricated using arc-melting in argon atmosphere. The examined compositions of the alloys were selected along the calculated composition changes in solid solution area. Interstitial impurities such as oxygen, carbon, and nitrogen were less than 200wppm in the ingots. The TEM disk specimens were cut out from the ingots, and annealed at 1400°C in vacuum. Neutron irradiation was performed in fast test reactor "JOYO" at JAEA. The irradiation damages and temperature ranges were 0.17-1.54dpa and 400-750°C respectively. As the post irradiation experiments, Vickers hardness test, TEM observation and electro resistivity measurement were performed.

There was clear difference between Re and Os in effects to irradiation hardening. In the case of W-Re alloys, when damages were less than 0.40dpa, the irradiation hardenings were nearly equal to pure tungsten independently on Re addition. But when the damage was 1.54dpa, the irradiation hardenings increased linearly with Re content. Microstructural observations showed that precipitations mainly formed in W-Re alloys. In the case of W-Os alloys, the irradiation hardenings of W-3Os alloys were 400 larger than those of pure tungsten independently on dpa and irradiation temperature. Effects of microstructure evolution on hardening and electro resistivity will be discussed.

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