High temperature mechanical properties of group 5 metals and their alloys for tritium permeation materials

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In the liquid breeder blanket systems, one of key issues is the tritium extraction from the breeder materials, such as molten salt Flibe, liquid metal lithium and lithium lead eutectic. Several mechanisms are proposed as the extraction method, namely hydrogen permeation thorough metal wall, breeder-gas diffusion, hot or cold trapping and so on. Group 5 metals, such as V, Nb and Ta, and their alloys are potential high hydrogen permeation materials for the metal wall permeation system. The tritium recovery system should be operated at high temperature, to keep the breeder temperature high, leading to high thermal efficiency of the blanket system. The purpose of the present study is to evaluate the mechanical properties of the candidate materials, and their applicability to high temperature operation.

Materials used were pure V, Nb, Ta, and Nb-9.4 wt% W (Nb-5 mol% W) alloy. Pd-25wt%Ag, the practical hydrogen permeation material, was also prepared for the reference. Their plates of 1 mm in thickness were cold-rolled into 0.25 mm-thick sheets. Small size tensile specimens with gauge sizes of 5 x 1.2 x 0.25 mm were punched out from the sheets. The specimens were annealed at 773-1070 K for 1 hr in a vacuum. Vickers microhardness tests were performed at room temperature. Tensile tests and creep tests at 823 to 1073 K were conducted in a vacuum condition.

The hardness of pure V, Nb, Ta and Pd-Ag alloy after cold rolling was 127, 124, 170 and 220 Hv, respectively, while were recovered to 82, 73, 150 and 102 Hv after annealing at 1073 K. Ultimate tensile strength of them after the annealing was 160, 126, 268 and 240 MPa, respectively, at 873 K tests. The hardness and the tensile strength of pure Ta were higher than those of the other materials, therefore it likely maintained work hardening due to its high thermal resistance to dislocation recovery. Tensile and creep properties of Nb-9.4 wt% W alloy will be also reported in the present study.

This work was supported by JSPS KAKENHI Grant-in-Aid for Scientific Research (A) 21246141 and NIFS budget code NIFS09UCFF002.