§34. Applicability Study of Hydride Materials for Neutron Shielding in a DT Fusion Reactor

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In a fusion reactor design, distance between core-plasma and superconducting coils is one of important factors to decide a reactor size, magnetic field strength for plasma confinement etc. To reduce the distance, a thinner radiation shield layer with high density neutron shielding materials must be installed in a reactor. Metal hydrides, such as titanium, zirconium, and vanadium hydrides, are focused as the shielding material because they can include higher density of hydrogen atoms than liquid hydrogen. It is difficult to fabricate the bulk non-crack metal hydride because of the brittleness and ~20 % of volume change in the hydrogenation. Additionally, large amount and high accuracy of dimension are needed as the hydride shielding materials in fusion reactor. In the present study, to simplify the fabrication process, we tried to make dense titanium and zirconium hydride pellets by cold-pressing from their powders. In this case there is a concern about reduction of the thermal conductivity due to the low-density and weak contact between the particles. Low thermal conductivity raises the operation temperature and causes the hydrogen desorption, therefore the thermal conductivity of hydride pellets should be examined.

Commercial ε-titanium hydride powder (Aldrich, 99 % purity) was used as a starting material. The powder was pelletized by cold-pressing with pressure of 50 MPa ~ 910 MPa. The density was calculated from the weight and dimensions. The thermal diffusivity was measured by laser flash method using Netzsch LFA457. Using literature data of heat capacity [1], thermal conductivity, κ, was estimated by

$$\kappa = \alpha C_P d,$$

where α, C_P, d were thermal diffusivity, heat capacity and sample density.

Fig. 1 shows a SEM image of ε-titanium hydride pellet. The pressure at cold-pressing is 910 MPa. The particles appear to deform by the pressing and 90 % of the theoretical density is achieved by the condition. It is noted that the titanium becomes softened by hydrogen [2], which might provide the high density only by the cold-pressing. The relation between the relative sample density and pressure is shown in Fig. 2 together with the result of ε-zirconium hydride. With increasing the pressure, the sample density increases linearly. For both titanium and zirconium hydrides, 90 % of theoretical density was achieved by cold-pressing.

The estimated thermal conductivity of ε-titanium hydride and ε-zirconium hydride are shown in Fig. 3. The value increases with the density. The temperature dependence is relatively weak, which indicate the thermal conduction was dominated by the electrons. With comparison to the thermal conductivity: ~20 $Wm^{-1}K^{-1}$ for the bulk sample [3], the fabricated sample shows comparable value of 14 $Wm^{-1}K^{-1}$ at room temperature. It attributes to the strong contact between the particles. The titanium hydride structure fabricated by cold-pressing can be a candidate of the shielding material in a fusion reactor.

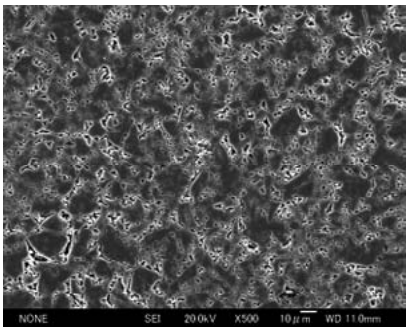

Fig. 1. SEM image of ε-titanium hydride pellet.

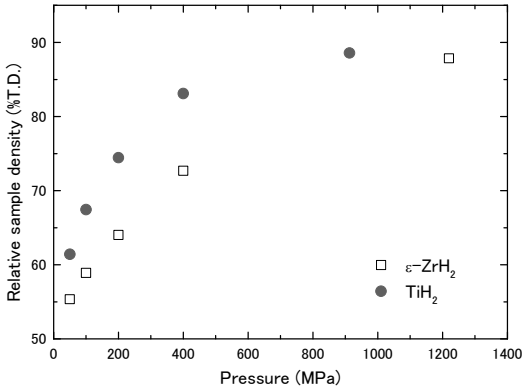

Fig. 2. Relative sample density of ε-titanium hydride and zirconium hydride pelletized by cold pressing.

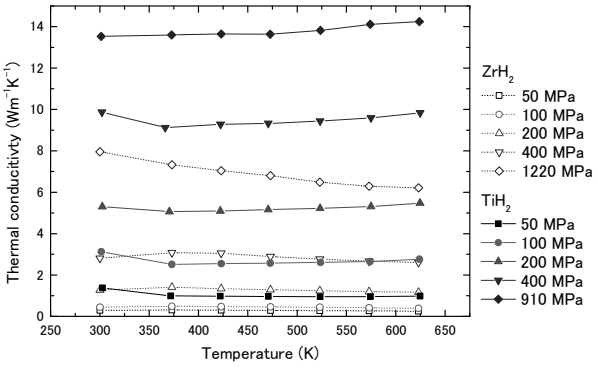

Fig. 3. Temperature dependence of thermal conductivity of ε-titanium hydride and ε-zirconium hydride.

1) Yamanaka, S. et al., J. Alloys Compd., **330-332** (2002) 99.
2) D. Setoyama, J. Matsunaga, H. Muta, M. Uno, S. Yamanaka, *J. Alloys Compd*, **381** (2004) 215–220.
3) D. Setoyama, J. Matsunaga, M. Ito, H. Muta, et al., *J. Nucl. Mater.*, **344** (2005) 298–300.