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

Muta, H., Araki, D. (Osaka Univ.),
Muroga, T., Hishinuma, Y., Tanaka, T.

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. . Zirconium hydride, which can include higher density of hydrogen atoms than liquid hydrogen, is focused as the shielding material at the present study. It is difficult to fabricate the bulk non-crack zirconium hydride from zirconium metal, because the zirconium hydride is brittle and the metal zirconium expands by hydrogenation by ~20 %. It is known that the zirconium hydride leads to hydride embrittlement in the nuclear fuel cladding of light water reactors. It needs about one or two weeks for fabrication of 10 mm-sized zirconium hydride from the metal zirconium [1,2]. To simplify the fabrication process, we tried to make dense zirconium hydride pellets from the powder. Additionally, the thermal conductivity, that is important for reactor design, is estimated.

Commercial ε-zirconium hydride powder (Aldrich, 99 % purity, 50 mesh) was used as a starting material. The powder was pelletized by cold pressing with pressure of 50 MPa to 400 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, 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 ε-zirconium hydride disk fabricated by cold pressing. The relation between the relative sample density and pressure is shown in Fig. 2. With increasing the pressure, the sample density increases linearly. Sample with 73 % of theoretical density is obtained by 400 MPa pressure. It can be increased by using the fine powders.

The estimated thermal conductivity is 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: ~80 $Wm^{-1}K^{-1}$ for the bulk sample [3], the pressed sample has significantly lower values, unfavorable for reactor design because it rises the temperature and makes difficult to cool down. More densification by powder treatment is needed.

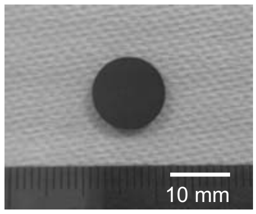

Fig. 1. ε-zirconium hydride pellet.

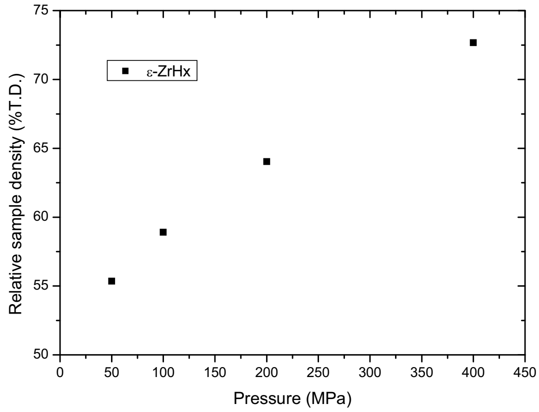

Fig. 2. Relative sample density of ε-zirconium hydride pelletized by cold pressing.

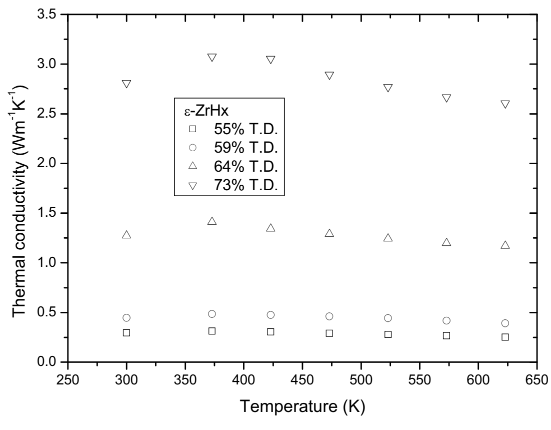

Fig. 3. Temperature dependence of thermal conductivity of ε-zirconium hydride disks.

1) Yamanaka, S. et al., J. Alloys Compd., **330-332** (2002) 99.
2) Uno, M. et al., J. Alloys Compd., **366** (2004) 101.
3) Tsuchiya, B. et al., *J. Alloys Compd.*, **330-332** (2002) 357.