§37. Improvement of Weight Density and Thermal Conductivity of Hydride Neutron Shielding Material using Metal Coated Powder

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To reduce a fusion reactor size, a thinner radiation shield layer with high density neutron shielding materials must be installed. Metal hydrides are promising as the shielding materials[1)] because they can include higher density of hydrogen atoms than liquid hydrogen. However, it is known that the bulk non-crack metal hydride is difficult to fabricate due to the brittleness and the large volume change in the hydrogenation. Previously, to simplify the fabrication process, we tried to make dense hydride pellets by cold-pressing from their powders[2)]. More than 80 % of theoretical density and acceptable thermal conductivity could be obtained by the simple process. In the present study, to improve the density and the thermal conductivity, metal coating on the hydride powders were examined.

Commercial ε-titanium hydride (TiH_2) (Aldrich, 99 % purity) was used as a starting material. The powders were coated by copper (Cu) by using electroless Cu plating process at room temperature. The plating solution was C-200LT (Japan Pure Chemical Co., LTD). TiH_2 powder was mixed by using a magnetic stirrer for several hours. After plating, the powder was washed by ethanol. Then the powder was pelletized by cold-pressing with pressure of 400 MPa. We fabricated three samples with different Cu amount of 0.4, 5.8, 25.8 at%. The density was calculated from the weight and dimensions. The relative density was estimated from Ti/Cu ratio evaluated from SEM-EDX analysis. The thermal diffusivity, α, was measured by laser flash method using Netzsch LFA457 to calculate the thermal conductivity, κ, from the equation of $\kappa = \alpha\ Cp\ d$. Cp and d are heat capacity and sample density, respectively.

Figure 1 shows XRD patterns for the samples. Only peaks from TiH_2 and Cu phase are seen, no peak shift is detected. SEM image of the TiH_2–Cu mixed pellet with 5.8 at% of Cu is shown in figure 2. Small particles of Cu are distributed in gap of the large TiH_2 particles.

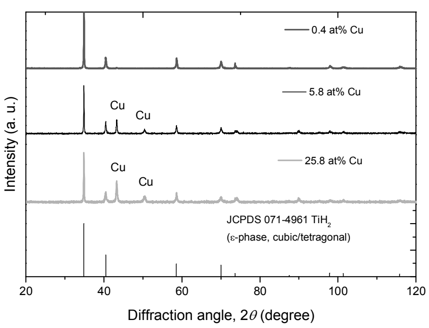

Fig. 1 XRD patterns of Cu coated TiH_2 powders.

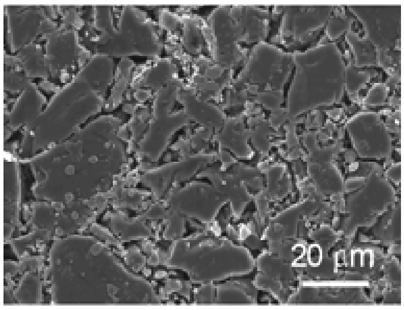

Fig. 2 SEM image of TiH_2-5.8 at% Cu mixed pellet.

Table 1 shows relation between Cu amount and densities of pressed pellets. Due to the Cu coating, the relative density of the 5.8 at% Cu sample increases from 83 %[2)] to >90 %. The Cu particles appears to act as lubiricant, which might promote the particle displacement at the cold-pressing. However, Increase of the relative density is not seen for 0.4 at % and 25.8 at% Cu added pellets. The reason remain unclear.

Table 1 Cu amount and relative densities.

Cu amount		Relative density (%)	TiH_2 density (%)
(at%)	(vol%)		
0 [2)]		83.1	83.1
0.4	0.2	83.7	83.5
5.8	3.2	103	99.5
25.8	15.8	83.1	70.0

The temperature dependence of thermal conductivity is shown in figure 3. The thermal conductivity of 5.8 and 25.8 at% Cu-added samples is almost same as that for pure pressed TiH_2[2)] in spite of the Cu addition. The thermal conductivity of pure Cu is more than 300 $Wm^{-1}K^{-1}$ at room temperature, so the TiH_2-Cu mixed sample should has higher thermal conductivity. It probably be caused by the contamination at the Cu/TiH_2 interface and the surface oxidation of the particle at the non-electrolytic plating. Because of the oxidation, 0.4 at% Cu-added sample shows lower thermal conductivity. Appropriate Cu amount and plating condition should be considered.

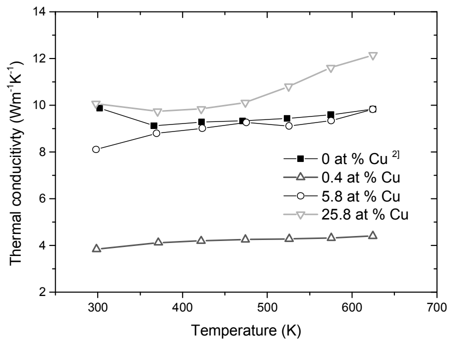

Fig. 3 Thermal conductivity of TiH_2-Cu mixed pellet.

1) Tanaka, T. et al : Fusion Sci. Technol., accepted.
2) Muta, H., Tanaka, T. et al. : Plasma Fusion Res. 10 (2015) 021.