§2. Fabrication of Hydride Blocks for Neutron Shielding in Fusion Reactors and Examination of Hydrogen Release Properties

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Since atomic concentrations of hydrogen in metal hydride materials such as ZrH_2, VH_2, $Mg(BH_4)_2$ are comparable with that in water, they are attractive neutron shielding materials for fusion reactors.[1-3] However, studies on the materials have been limited in neutronics investigation, i.e. neutron transport calculations, in reactor design activities. Fabrication of ZrH_2 and TiH_2 blocks from hydride powders and property investigation of the hydrogen release are conducted in the present study.

In neutronics benchmark experiments using a DT neutron source, blocks of ~50 x 50 x 50 mm^3 – 50 x 50 x 200 mm^3 are used for construction of irradiation assemblies.[4] Although the size was smaller than them, test fabrication of TiH_2 blocks of ~25 x 25 x 5 and 25 x 25 x 12.5 mm^3 was performed by die pressing of powders at room temperature. The maximum pressure in the fabrication was 200 MPa. Densities of the blocks were compared with our previous results for 10 mmϕ x ~2.5 mm discs (Fig. 1). The densities of 5 mm thick blocks were similar to those of the 2.5 mm thick discs. However, decrease in the densities was found for the 12.5 mm thick blocks. During the test fabrication of the large blocks with high pressures, the inner die surfaces were easily damaged by friction with TiH_2 powders. Therefore, block fabrication by the cold isostatic press (CIP) method at 200 MPa was tested after the die pressing with lower pressures. In case of the 5 mm thick blocks, the densities were almost same as those fabricated only by the die pressing process. Fabrication of 25 x 25 x 12.5 mm^3 or larger TiH_2 blocks, and ZrH_2 blocks is under study by the CIP method.

Regarding hydrogen concentrations in hydrides in equilibrium conditions, relations with hydrogen pressures and temperatures can be retrieved from PCT (hydrogen pressure-concentration-temperature) curves in the literature. However, hydrogen release properties in air are required for investigation of accidental situations. In the present study, oxidation properties of the ZrH_2 and TiH_2 powders at high temperatures were examined by detecting the weight changes with the thermal gravity (TG) analysis. Hydrogen released at high temperatures was measured simultaneously by a quadrupole mass spectrometry (QMS) system connected to the TG system. Figure 2 shows the hydrogen release properties of the powders in Ar and air flows. The results indicate that hydrogen releases from both the powders start at lower temperatures in an air flow compared with the releases in an Ar flow. The weight increases due to oxidation in an air flow start at the same temperatures in the TG measurements. In case of the ZrH_2 powder, the peak temperature of the hydrogen release also decreased due to the oxidation. Although the peak temperature for the ZrH_2 powder in an air flow was still higher than that for the TiH_2 powder, the temperature starting the hydrogen release was lower by more than 100 ^oC compared with the TiH_2 powder. This would be one of important factors in the material selection and atmosphere control in radiation shield units for fusion reactors.

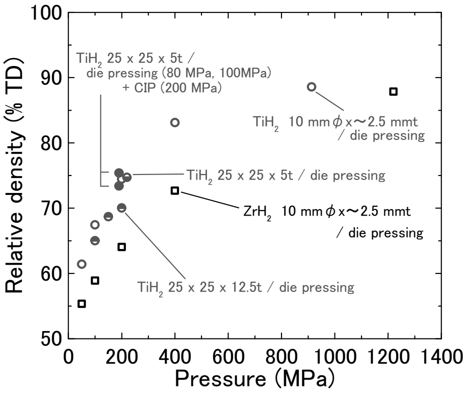

Fig. 1. Relative densities obtained for 25 x 25 x 5 and 25 x 25 x 12.5 mm^3 die pressed TiH_2 blocks and 25 x 25 x 5 mm^3 CIP TiH_2 blocks. (TD: Theoretical density)

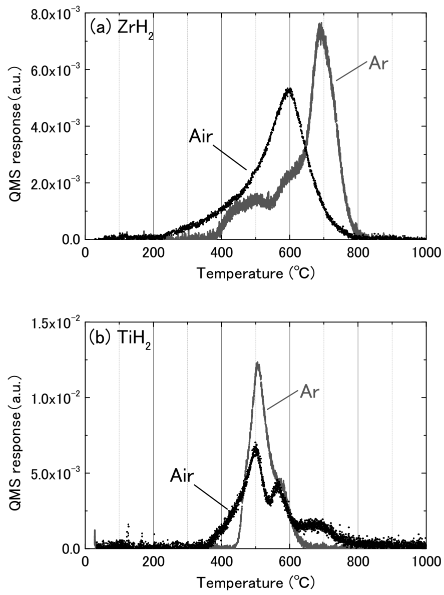

Fig. 2. Hydrogen release from (a) a ZrH_2 powder and (b) TiH_2 powder in Ar and air flows. The heating rate was 3 ^oC/min.

1) Hayashi, T. et al., Fusion Engineering and Design **81** (2006) 1285.
2) Nishitani, T. et al., Fusion Engineering and Design **81** (2006) 1245.
3) Chen, Y. et al., FZKA 6763, Forschungszentrum Karlsruhe GmbH, Karlsruhe, (2003).
4) Tanaka, T. et al., Fusion Science and Technology **60** (2011) 681.