§31. Thermal Diffusivity Measurements of Candidate Ceramic Materials for Shielding Blankets

Akoshima, M., Yamashita, Y. (AIST),
Hishinuma, Y., Tanaka, T., Muroga, T.

On the helical-typed DEMO reactor design activity in NIFS, Carbides and metallic hydrides are considered as candidate materials of shielding blankets. These materials are expected to have some advantages from the view of nuclear properties and thermophysical properties. There are needs of reliable thermophysical properties for thermal design of the fusion reactor. However, there are few published data on thermophysical properties, for example, thermal conductivity, thermal diffusivity, and specific heat capacities of carbides and hydrides.

Thermal conductivity is the most popular quantity to express the property of heat conduction. In the case of bulk material, thermal conductivity is often calculated from thermal diffusivity, heat capacity and density because thermal diffusivity can often be measured easier than thermal conductivity.

The laser flash method[1)] is one of the most popular methods of thermal diffusivity measurement for mm order thick solid materials. It is usually used in the temperature range from room temperature to over 1000 K. This method has features of non-contact, non-destructive and short-time measurement. Thermal diffusivity obtained by the method is known reliable since the method is based on the one dimensional heat diffusion phenomena. National Institute of Advanced Industrial Science and Technology (AIST) has investigated the laser flash method to establish the standard of thermal diffusivity measurement[2)]. We developed some techniques to obtain thermal diffusivity as an absolute value and as an intrinsic physical property

In this study, we measured thermal diffusivity of Tungsten Carbide (WC) and Boron Carbide (B_4C) using the flash method in order to investigate thermal property of these materials.

The disc shaped samples with 10 mm diameter and different thicknesses of WC and B_4C were prepared for this study. Especially, two kinds of B_4C were given which consist of condensed boron and natural boron. These specimens were coated by Au sputtering thin film and graphite spraying in order to absorb pulsed laser beam and to avoid transparent for wave lengths of the laser beam and the infrared radiometer. At room temperature, we measured thermal diffusivity of all samples. And temperature dependences were investigated by one sample for each material.

The table 1 shows samples with thicknesses and measured thermal diffusivity at room temperature. The measured thermal diffusivities agree with each other independent of sample thickness for each material. The uncertainty of thermal diffusivity in Table 1 is 5% - 20%. Temperature dependences of thermal diffusivity of WC and B_4C are shown in Fig. 1. These are typical behavior of temperature dependence which is shown by ceramic materials. Thermal diffusivity of WC is larger than that of B_4C. And the range of thermal diffusivity for the temperature range from 300 K to 1000 K is smaller than that of B_4C.

The natural B_4C shows smaller thermal diffusivity rather than condensed B_4C for this temperature range. The difference between them is not significant because uncertainty of thermal diffusivity measurement is more than 5%.

From the literature survey, thermal diffusivity (or thermal conductivity) of WC has not been reported in the temperature range from above room temperature to 1000 K. Consequently, our results are useful for the thermal design of shielding blankets.

Table. 1 Thermal diffusivity at room temperature of WC and B_4C.

Material	Thickness / mm	Thermal diffusivity / m^2s^{-1}
WC	1.228	1.99×10^{-5}
	2.192	1.80×10^{-5}
	3.149	1.85×10^{-5}
Natural B_4C	3.047	1.61×10^{-5}
	5.128	1.68×10^{-5}
Condensed B_4C	3.121	1.43×10^{-5}
	5.111	1.58×10^{-5}

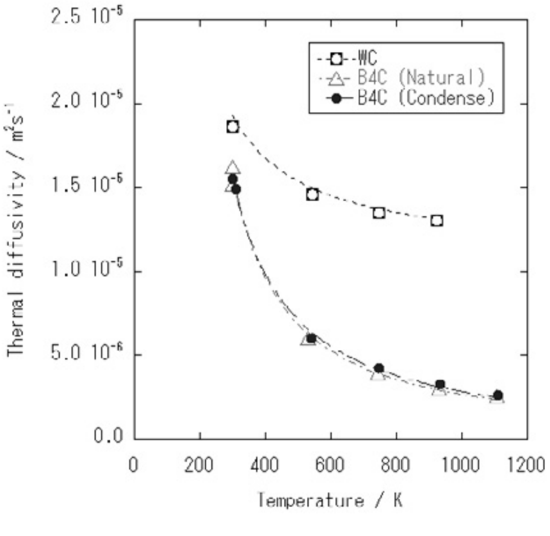

Fig. 1. Temperature dependence of thermal diffusivity of WC and B_4C.

1) W. J. Parker, R. J. Jenkins, C. P. Butler, G. L. Abbott: J. Appl. Phys. **32**, 1679 (1961).
2) M. Akoshima, T. Baba, Int. J. Thermophys., **27** (2006) 1189.