§28. Sintering Density Dependence on the Thermal Diffusivity of the Carbide Materials for Shielding Blankets

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Some carbides, for example, Tungsten Carbide (WC) and Boron Carbide (B_4C), and metallic hydrides are expected as candidate materials of thermal shield of the blanket system for Force Free Helical Reactor (FFHR). There are few published data on thermophysical properties, for example, thermal conductivity, thermal diffusivity, and specific heat capacities of carbides and hydrides comparing those of metals and oxides. Especially, there are no data which is validated whose reliability. According to this problem, we measured thermal diffusivity with reliability evaluation of WC, dense B_4Cs consist of enriched boron and natural boron, and low density B_4C with natural boron.[1)-3)] The blanket system as a structural material consists of carbides and stainless steels because they keep the structure. There is a need to evaluate thermal conductive property of the structural material as the next step.

Base on the background, apparent thermal diffusivity when B_4C plate put on stainless steel plate was investigated in this study. The dense B_4C specimen which consists of natural boron was used for measurements. It is 10 mm disk with about 3 mm thickness. We prepared 10 mm disks of SUS 316 of 0.01 mm and 0.05 mm in thickness. The B_4C specimen put with SUS316 specimen into the specimen holder (Fig. 1). A lens holder for 10 mm diameter lens was used as a specimen holder in this study. The B_4C side was heated by pulsed laser beam and SUS316 side which is coated by the carbon spray was observed by an infrared radiometer.

Fig. 2 shows temperature rise curves observed by the laser flash method. The curve of B_4C specimen (black) is beautiful signal and thermal diffusivity was estimated as 1.48×10^{-5} m^2/s. The curves of B_4C-SUS316 show enough S/N ratio for analysis to estimate thermal diffusivity. Note that the temperature rises become slow rather than that of B_4C specimen although thickness of SUS316 plate is enough thin.

Here, heat diffusion time of SUS316 plate in 0.05 mm thickness is about .0.6 ms. The apparent thermal diffusivity measurements were carried out several times with resetting specimens to the holder. The estimated apparent thermal diffusivities of B4C-SUS316(0.05 mm) were scattered from 2.97×10^{-6} m^2/s to 4.90×10^{-6} m^2/s. One curve (gray line) in Fig. 2 is a typical temperature rise curve which shows high apparent thermal diffusivity. The other (black line with circular simbols) shows that in the case of low apparent thermal diffusivity. It was found repeatability is now well. I was considered that thermal resistance between B_4C specimen and SUS316 plate changes every time. And strictly speaking, these temperature curves included non-uniform heating effect. The pulsed heated area was about 7 mm in diameter in the disk specimen in 10 mm diameter because the lens holder limit specimen surface. And specimen thickness of about 3 mm is relatively thick for surface diameter.

In summary, it was found that apparent thermal diffusivity of B_4C specimen with SUS 316 plate (0.05 mm thick) is lower than that of B_4C specimen. It is the order of 10^{-6} m^2/s. They were changed by reset specimen to the holder. In order to estimate more reliable tendency of apparent thermal diffusivity of the structural material, many repeated measurements with large specimens in diameter were needed.

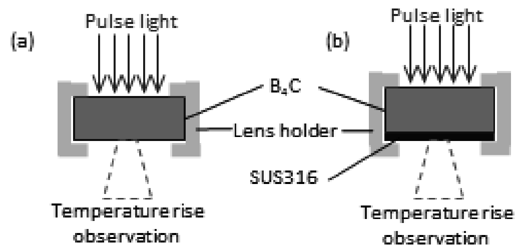

Fig. 1. Specimen settings to the lens holder. (a) B_4C specimen and (b) B_4C-SUS316 (0.05 mmt) .

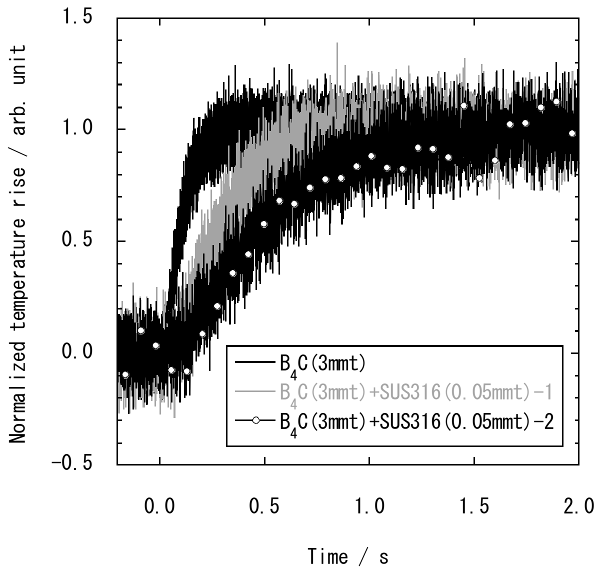

Fig. 2. Temperature rise curves of B_4C specimen and B_4C-SUS316 (0.05 mmt) .

1) Hishinuma, Y., Akoshima, M., Yamashita, Y., Tanaka, T., Sagara, A., Muroga, T., 23rd International Toki Conference (ITC-23), Toki, Japan 18-21. Nov. (2013)
2) Akoshima, M., Yamashita, Y., Hishinuma, Y., Tanaka, T., Sagara, A., Muroga, 20th European Conference on Thermophysical Properties, Porto, Portugal, 31. Aug. -4. Sep. (2014) and 35th Jpn. Symposium on Thermophysical Properties, Tokyo, Japan, 22-24 Nov. (2014).
3) Akoshima, M., Yamashita, Y., Hishinuma, Y., Tanaka, T., Sagara, A., Muroga, Annual Report of National Institute for Fusion Science: April 2014 – March 2015, p.331 (2015).