§60. Development of Boron System Ceramic Material for Divertor Plate

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The carbon for divertor material of the thermal conductivity decreased with increasing temperature. However, titanium boride (TiB_2) ceramics as the boron (B) system composite that a thermal conductivity improves caused with increasing temperature. It is shows the thermal conductivity, which is the superior graphite material at high temperature. Then, the TiB_2 ceramics has various desirable properties, including a high melting point (3253 K), high degree of hardness (Hv = 32 GPa), excellent electrical conductivity (10^7 S/m), and chemical stability[1]. It can be used for cutting tools, wear-resistant parts, electrodes for aluminum electrolysis, cathodes for MHD power generation, boats and crucibles for vapor deposition, etc.[2), 3)]. The dense sintered TiB_2 material was developed in Tokai University.

In this study, it was made that it constructed the database on characteristics at high-temperature condition for divertor plate and examines the application to fusion device to be a purpose in order to apply the TiB_2 ceramics with this excellent characteristics to fusion science. Then, the research was carried out in fusion science and cooperation in respect of the examination for applying the above-mentioned and excellent material features to fusion device using active cooling test equipment (ACT) of National Institute for Fusion Science.

The monolisic TiB_2 powder made by Idemitsu Materials Co., Ltd., Japan was enclosed with the carbon jig, and the TiB_2 sintered body was prepared by using hot-pressing method. The relative density of the TiB_2 sintered body was obtained by the Archimedes' measurement. The Relative density of the samples by hot pressing was 99 %. The coefficient of linear thermal expansion of the sample was carried out from the room temperature to 1000 K using thermal analysis equipment (TMA) made by Shimadzu Corp., Japan. The linear thermal expansion of the sample is shown in figure 1. The linear thermal expansion coefficient of the sample showed about 3 times the value of the graphite $(8 \times 10^{-6}$ / K). To data, this thermal expansion coefficient is same value as a metallic materials. In addition, the hysteresis could not be recognized in the sample. The sample of 20 × 20 × 10 mm in size produced by wire electric discharge machining (wire-EDM) was set and done to the coppered attachment for the ACT mounting in the silver solder, and thermal load evaluation test was carried out using the ACT. Then, the ACT test was also carried out on the isomorphic carbon sample in the silver solder in the similar attachment for the comparison. In addition, the sample was joined together by the silver solder bill treatment in the coppered attachment which newly made the thermometry place to be the 4 places were produced used diesinking EDM equipment. From the last year's research results of the ACT test, it was possible that the TiB_2 samples got the result to of be good to 4 MW thermal load. The thermal conductivity increased with increasing temperature in the heat load test to 4 MW. However, in the condition over 5 MW, the sample temperature rose over 1373 K, and there was the welding of K-type thermocouple installed in inside of sample. Then, the welding of thermocouple and sample could not be recognized to 10 MW in the carbon sample.

Therefore, the sample, which newly made the thermometry place to be the 4 places, was produced in this study. The heat load test over 5 MW became possible for the ACT test, because the thermocouple for the measurement of the temperature was changed from K-type to R-type thermocouple. In the condition over 5 MW, the sample temperature rose over 1373 K, and there was the welding of K-type thermocouple installed in inside of sample.

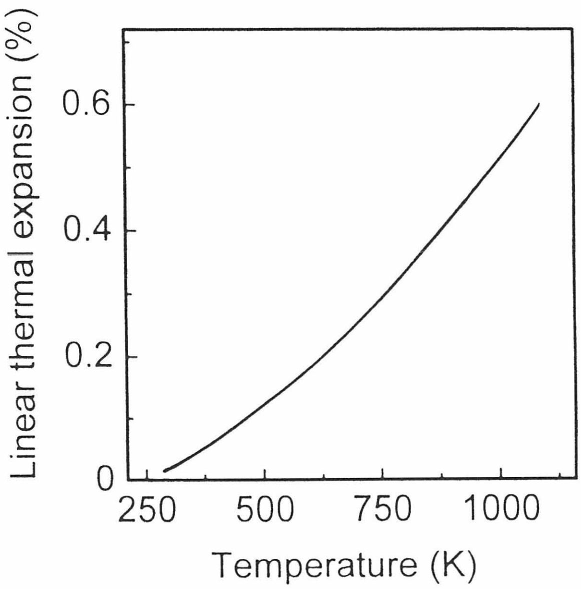

FIG. 1. Linear thermal expansion of TiB_2 sintered body as a function of mesurment temperature.

References

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