§17. Development of Low Z Ceramics for Divertor Plate

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Low atomic number element ceramic is excellent candidate materials for the divertor plate of fusion materials. Silicon hexaboride (SiB_6) of low atomic number (Z) B element system ceramics has proved to be a potentially useful material because of its favorable properties, such as high melting point, high Vickers hardness, chemical stability and excellent electrical conductivity.1) Silicon chemical compound of boride such as SiB_4, SiB_6, SiB_{6-x}, SiB_{6+x}, SiB_{14}, $Si_{8.44}B_{305.51}$, and $Si_{11}B_{31}$, have been registered in the X-ray cards of the International Center for Diffraction Data (ICDD). The graphite of the low atomic number materials is used as a divertor for plasma facing materials.2) The thermal conductivity of graphite decreases, as the crystallite is smaller, and decrease with decreasing temperature. On the other hand, the erosion damage by sputtering of the hydrogen isotope ion of graphite is severe. For that reason, there is a problem that the density control of the plasma is difficult.3) The development condition of excellent divertor materials in the thermal load is probably required to have high melting point and high thermal conductivity. 4)

Therefore, SiB_6 ceramics is the promising divertor candidate materials. Unfortunately, although monolithic SiB_6 is known to be chemical stability up to high temperatures. However, there have only been few reports regarding the high temperature properties of silicon boride ceramics.

In this study, the mechanical, electrical, and thermal properties at high temperature of the SiB_6 ceramics was investigated in order to determined the possibility of its divertor materials at plasma environment in nuclear fusion reactor.

SiB_6 powder was used commercial material as starting materials (one batch for all tests). The purity and median particle size of powder listed in a catalogue are 98 % and 2 μ m, respectively. The powder was packed in a carbon vessel in a resistance furnace provided with carbon heating elements and hot pressing sintered under 10^{-4} Pa vacuum at 1823 to 1923 K for 1 h under 40 MPa pressure. It was heated at 15 K/min; but after sintering, the molded substance was allowed to cool slowly in an argon gas atmosphere. The size of sintered body for specimen was about 20 mm × 20 mm × 5 mm.

The bulk density of the sintered body was measured by the Archimedes' method. The relative density of the sintered body was obtained by calculating the ratio of the bulk density to the theoretical density of SiB_6 (2.42 g/cm^3). The samples were subjected to X-ray diffraction analysis for phase evolution using a powder X-ray diffractometer. The surfaces of the sintered specimens were observed using a scanning electron microscope (SEM) to estimate the microstructures.

Figure 1 shows the relationship between the sintering temperature and the relative density of the sintered body. The relative density of the monolithic SiB_6 sintered body increased with increasing sintering temperature. In the case of the sintering temperature of 1923 K, a sintered body having a relative density of more than 99 % was obtained. The X-ray diffraction data of the sintered bodies only showed peaks of SiB_6 of as-received. The result of the X-ray diffraction showed no crystalline phase other than SiB_6 in the sintered bodies. The polish surfaces of the samples were observed using a SEM. The surface of the sintered body showed many pores in the sintered at 1823 to 1873 K. In the meantime, the sample of the sintered at 1923 K supposes that it is pore free and made into the densification.

The sintering conditions of SiB_6 ceramics produced by hot pressing were investigated in order to determine the suitability of its divertor. The relative density increased with increasing sintering temperature. In the case of the sintering temperature of 1923 K, a sintered body having a relative density of more than 99% was obtained.

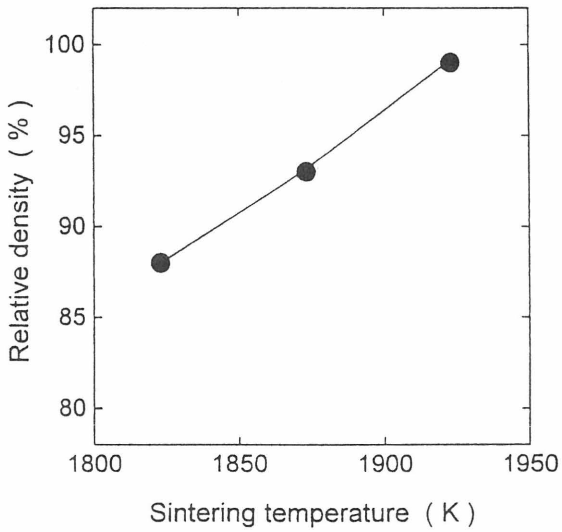

FIG. 1. Relationship between sintering temperature and relative density of the sintered bodies.

References

1) Olesinski, R. W. et al. : Binary Alloy Phase Diagrams, **5** (1984) 478.
2) Committee of Japan Materials Society, Kyokugen Jyotai To Zairyo, Syokabo, Tokyo (1977) 142.
3) Jinbou, R. et al. : J. of the Ceram. Soc. of Jpn., **105** (1997) 1091.
4) Committee of New Materials Handbook, New Materials Handbook, Tokyo (1988) 402.