§25. Development of SiC Material for Flow Channel Insert in Liquid Blanket System

Hinoki, T., Lee, Y. (Institute of Advanced Energy, Kyoto Univ.),
Tanaka, T., Muroga, T.

Silicon carbide fiber reinforced silicon carbide matrix (SiC/SiC) composites are considered as functional-structural materials for advanced energy systems, because of their excellent thermal, mechanical and chemical stability, and the exceptionally low radioactivity following neutron irradiation. In particular, flow channel inserts (FCIs) made of SiC/SiC composites were proposed as a means for thermal-insulation (< 2W/mK) to protect exterior metal materials [1-3]. The SiC/SiC composites consist of three constituents: SiC fiber, SiC matrix and Carbon interface layer. Of these, thermal conductivity can be controlled in the SiC matrix by porosity. In this study, Porous-SiC (P-SiC) ceramics was developed for low thermal conductivity. Thermal conductivity of P-SiC ceramics with various range of porosity was measured to confirm insulation property.

In the collaborative study, P-SiC ceramics were fabricated by LPS method (LPS: Liquid Phase Sintering) at Kyoto university. The P-SiC ceramics were made from SiC slurry including carbon powders. The SiC ceramics including carbon powders were sintered by hot-press at 1850℃ in Argon. The sintered ceramics were decarbonized at 700℃ in air and pores were formed. The bulk density of the P-SiC ceramics was measured by the Archimedes method with an immersion medium of distilled water. Thermal conductivity was calculated using the measured bulk density, thermal diffusivity and specific heat capacity were measured by the laser flash method using a thermal analyzer. The thermal conductivity of SiC ceramics, K, can be determined by the thermal diffusivity, α, the specific heat, Cp, and the density, ρ, using the following expression.

$$K = \alpha \, C_p \, \rho$$

The microstructure of SiC ceramics was observed by FE-SEM.

For porosity of P-SiC ceramics, carbon powder was used at 20, 30, 40 and 50 vol%. Figure 1 shows microstructure of various P-SiC ceramics. The porosity of P-SiC ceramics were increased with increment of carbon volume.

Figure 2 shows thermal conductivity of various P-SiC ceramics. The thermal conductivity of P-SiC_20% with 20% porosity was decreased from 50.3W/mK at room temperature to 18.4W/mK at 1200℃, that of P-SiC_30% was decrease from 22.5W/mK to 12.1W/mK, that of P-SiC_40% was decreased from 13.4W/mK to 7.3W/mK and that of P-SiC_50% was decreased from 8.0W/mK to 4.1W/mK, respectively. The thermal conductivity of P-SiC ceramics was decreased with increasing porosity. It is possible to achieve < 2W/mK in service condition utilizing P-SiC considering decreasing of thermal conductivity under neutron irradiation.

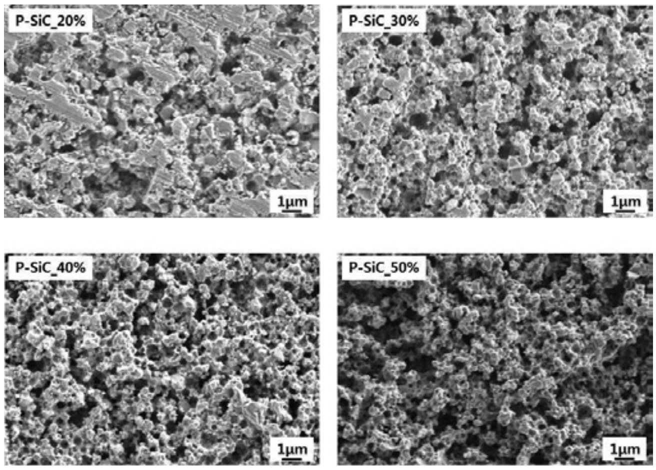

Figure 1 Microstructure of various P-SiC ceramics ; P-SiC_20%, 30%, 40% and 50%.

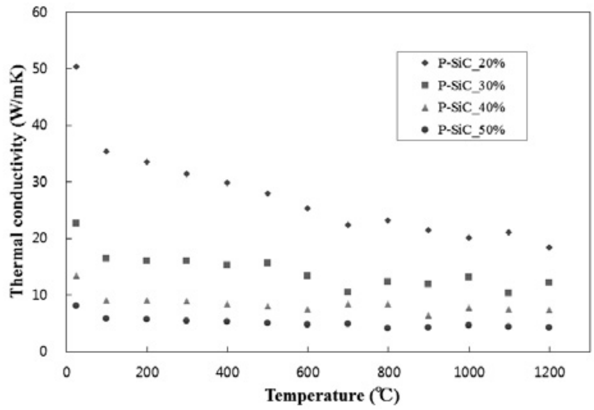

Figure 2 Thermal conductivity of P-SiC ceramics

1) P. Norajitra, L. Buhler, U. Fischer, S. Gordeev, S. Malang and G. Reimann, Fusion Engineering and Design, 69 (2003) 669-673.
2) F. Najmabadi and The ARIES Team, Fusion Engineering and Design, 65 (2003) 143-164.
3) M. Abdou, D. Sze, C. Wong, M. Sawan, A. Ying, N.B. Morley and S. Malang, Fusion Sci. Tech., 47[3] (2005) 475-487.