§8. Effect of Constituents on Thermal and Electrical Conductivity of SiC/SiC Composites

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Silicon carbide composites (SiC/SiC) are considered for use in extremely harsh environments at high temperature primarily due to their excellent thermal, mechanical and chemical stability, and the exceptionally low radioactivity following neutron irradiation. In particular, recent improvement in the crystallinity and purity of SiC fibers and improved composite processing have improved physical and mechanical performance under harsh environments. The novel processing called Nano-powder Infiltration and Transient Eutectic-phase (NITE) Processing has been developed based on the liquid phase sintering process modification 1). The NITE processing can achieve both the excellent material quality and the low processing cost. Recently, application of SiC/SiC is expanding. Various ranges of properties are required in particular for thermal and electrical conductivity 2). One of important advantages for SiC/SiC is tailorability. Properties of SiC/SiC can be controlled by constituent properties and its volume fraction. It is known that electrical conductivity of SiC was affected by fabrication conditions and impurities significantly. The objective of this work is to obtain fundamental knowledge regarding effect of constituents on thermal and electrical conductivity of SiC/SiC composites and tailorability of the thermal and electrical conductivity.

The material used was monolithic SiC fabricated by the same condition to form matrix of NITE-SiC/SiC composites and Hexoloy® SA SiC (sintered α-SiC). The sandwich material of Hexoloy SA SiC/monolithic NITE SiC/Hexoloy SA SiC was also used to evaluate the tailorability of the electrical and thermal conductivity of SiC. The monolithic NITE SiC was fabricated using the slurry including SiC nano-powder (<20nm) and the sintering additive of Al_2O_3, Y_2O_3, SiO_2. They were hot-pressed at 1800 ºC with the pressure 20 MPa in Ar environment. In case of the sandwich material the monolithic NITE SiC was formed by the same condition between Hexoloy SiC. The specimen was machined to 10 mm-square and 1mm-thick. The sandwich material had approximately 0.1 mm-thick NITE-SiC layer in the middle of specimen. To evaluate electrical conductivity, a center electrode and a guard electrode were made on the surface by Pt sputtering for current measurement and prevention of the leakage current through the side surface, respectively. On the other surface, an electrode was made for voltage supply. The conductivities were examined by measuring the induced current through the bulk of the specimens. A laser flash method was used to evaluate thermal conductivity.

Figure 1 shows the results of electrical conductivity. The electrical conductivities of Hexoloy SA SiC, NITE-SiC and the sandwich material were $0.9\text{-}1.1\times10^{-6}$ S/m, $2.2\text{-}3.2\times10^{-2}$ S/m and $0.8\text{-}1.3\times10^{-6}$ S/m, respectively. The electrical conductivity of the sandwich material was basically determined by rule of mixture. However the electrical conductivity of Hexoloy SA and NITE SiC is so different that it was mostly determined by Hexoloy SA with the lower electrical conductivity material than that of NITE-SiC. It was reported that electrical conductivity of the other high purity SiC was $\sim5\times10^{-12}$ S/m. It is considered that electrical conductivity of SiC can be tailored in combination of different SiC in wide range. The thermal conductivities of Hexoloy SA SiC, NITE-SiC and the sandwich material were 98 Wm/K, 27 Wm/K and 47 Wm/K, respectively. The thermal conductivity also showed relatively wide range although it seemed small compared with the range for the electrical conductivity. The thermal conductivity of the sandwich material was basically determined by rule of mixture. Thermal conductivity of the sandwich material was reduced to half approximately due to low thermal conductivity of the NITE SiC layer. Both electrical conductivity and thermal conductivity of the sandwich materials were consistent with the results for constituents. The thermal conductivity also can be tailored by combination of different SiC. The mechanical properties of both Hexoloy SA SiC and NITE SiC are relatively close. It can be concluded that electrical conductivity and thermal conductivity is tailored by combination of different SiC without significant change of mechanical properties.

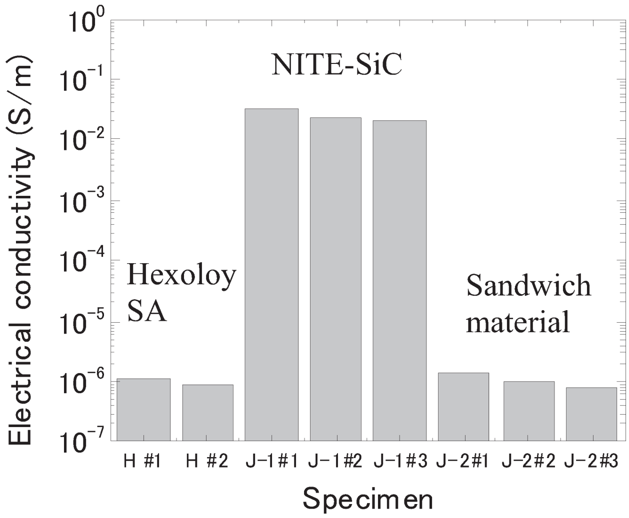

Figure 1: The electrical conductivities of Hexoloy SA SiC, NITE-SiC and the sandwich material

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