§6. Technical Evaluation of SiC Ceramic-Based Plasma Facing Components

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Silicon carbide (SiC) -based ceramics and composites are potentially attractive materials for plasma-facing components in fusion devices due to their superior radiation-resistance, reduced activation and low after-heat properties and heat-flux capacity. The objective of this work is, through technical evaluation of SiC fiber-reinforced SiC matrix composites (SiC/SiC composites), to identify engineering issues for this material class for fusion plasma-facing applications.

For this purpose, the engineering technique to develop a panel of SiC/SiC composites was investigated applying the NITE (nano-infiltration and transient eutectic-phase) process, which is an innovative process to fabricate SiC/SiC composites developed at Kyoto University. The engineering data for the panel including basic mechanical properties, thermal properties and gas permeability were obtained. The coating techniques of high Z materials on SiC/SiC composites were also developed to reduce the introduction of power-sapping impurities into the plasma and to reduce erosion.

The processing to develop the panel includes (1) the pretreatment of the SiC fibers, (2) C coating on the fibers, (3) the optimization of the slurry of the raw materials for matrix, (4) the fabrication of the perform, and (5) the infiltration of the raw material into the perform and the hot-pressing. The large panel with 200 × 200 × 4 mm as shown in Figure 1 were successfully developed by the controlling the temperature distribution and the additive. One of the engineering data obtained in this work is the gas permeability of the composites. Figure 2 is the comparison of helium permeability among various SiC/SiC composites and monolithic NITE-SiC. Monolithic SiC by NITE process keeps its permeability at the level of 10-12m^2/s, which is near the level of ordinary metallic materials. Laboratory products of NITE SiC/SiC present 10^{-11} to 10^{-9} m^2/s and the first pilot production of NITE SiC/SiC was not as good as laboratory products, although the level of 10^{-8} m^2/s is still outstanding comparing with other SiC/SiC composite materials.

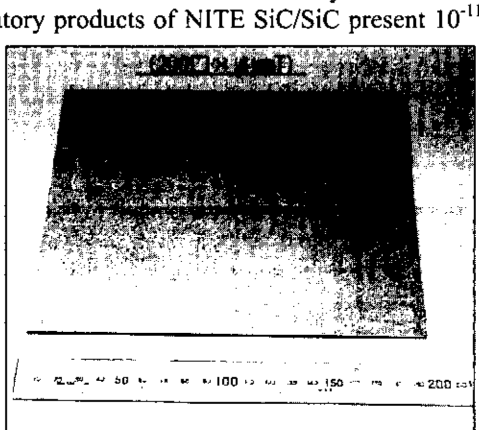

Figure 1. Appearance of a SiC/SiC composite panel fabricated by NITE process.

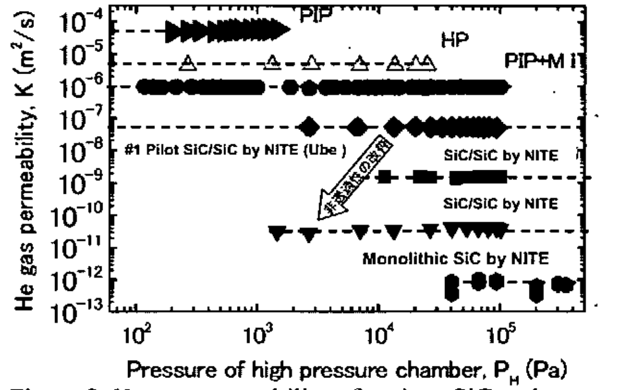

Figure 2. He gas permeability of various SiC and SiC/SiC composites.

As for the high Z material coating for SiC/SiC composites, tungsten was selected due to close coefficient of thermal expansion to SiC. The NITE technique was utilized for the development of the W armored SiC and SiC/SiC composites. In the case of W armored SiC, starting materials were both fine powders and by lay-up two zones of powders (slurry) followed by hot pressing, two layers of W and SiC were produced with strong bonding. By optimizing the materials used and process condition, SiC, W and their interface reaction layers can be controlled to make acceptable joining, bonding or claddings. Using the optimized condition, W armored SiC/SiC composites were developed. Figures 3 show the SEM images of the W armored SiC/SiC composites. The W armored SiC/SiC composites were successfully developed, although the optimization of processing for the composites is still required.

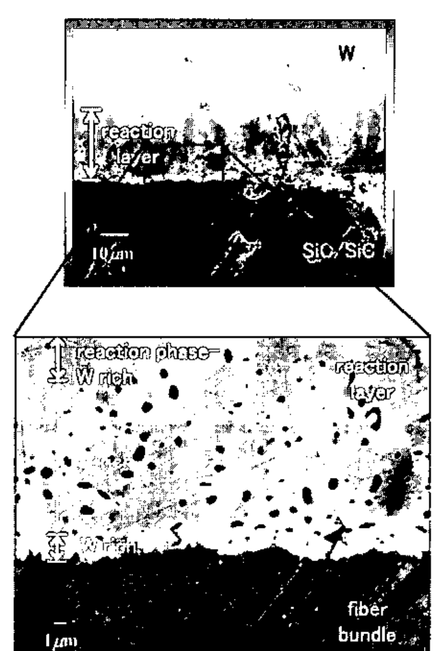

Figure 3. SEM images of tungsten armored SiC/SiC composites