§ 7. Development and Temperature Control of Ceramics Divertors

Tomota, Y., Kurumada, A., Imamura, Y. (Faculty of Engineering, Ibaraki Univ.), Oku, T. (The Univ. of the Air), Noda, N.

Ceramics (SiC/SiC composite, B_4C and others) are expected to use as a divertor for the LHD during continuous operation, long time and steady state discharges because of the high heat resistance and the excellent nuclear properties. In this study, divertor model specimens made of SiC/SiC composite materials were manufactured as one of the plasma facing components having high performances. And the integrity of the divertor model specimens was tested by a deflection-type electron beam heating apparatus.

The SiC/SiC composite material tested in this study was made by the polymer infiltration process (PIP) using the HI-NICALON SiC fiber.

Eight pieces of the SiC/SiC composite (20x2.5x5 mm) were joined with an oxygen free copper block (20x20x20 mm) having a cooling pipe (7 mm in inner diameter, 10 mm in outer diameter and 70 mm in length) after polishing and acetone washing. In the joining, titanium (0.05 mm in thickness) and copper (0.01 mm in thickness) foils were used, and a molybdenum plate (0.5 mm in thickness) was inserted for a relaxation of thermal stresses. The joining specimens were held for 30 minutes at 1000 degrees C in a vacuum of $1x10^{-5}$ Torr. [1,2]

Heat fluxes from 0.5 to 5 MW/m^2, that the one cycle was 10-sec irradiation and 15-sec interval, were irradiated to the divertor model specimens by the deflection-type electron beam heating apparatus. The water coolant speed was 15 l/min at 15 degrees C. Before and after the heat load tests, the microstructures of the joining parts were observed by SEM.

By insert of molybdenum, thermal cracks weren't observed at the joining parts and the shear strengths of the joining interfaces increased. So the good joint of the SiC/SiC composite divertor model specimen was confirmed.

Fig. 1 shows the SiC/SiC composite divertor model specimen after heat load tests. The surface temperature of the SiC/SiC composite material increased abruptly with increasing heat flux, the surface eroded remarkably and the pieces of the SiC/SiC composite material delaminated at the joining interface. On the other hand, the lower temperature of the joining part rose little. One of the reasons was considered that the heat didn't transfer sufficiently because of the low thermal conductivity and delamination cracks.

Consequently, the joining process of the SiC/SiC composite materials was established, however, the SiC/SiC composite material was necessary to be improved the thermal conductivity and the resistance to erosion as the next step task. These results were useful knowledge for the development of the ceramics divertor having high performances.

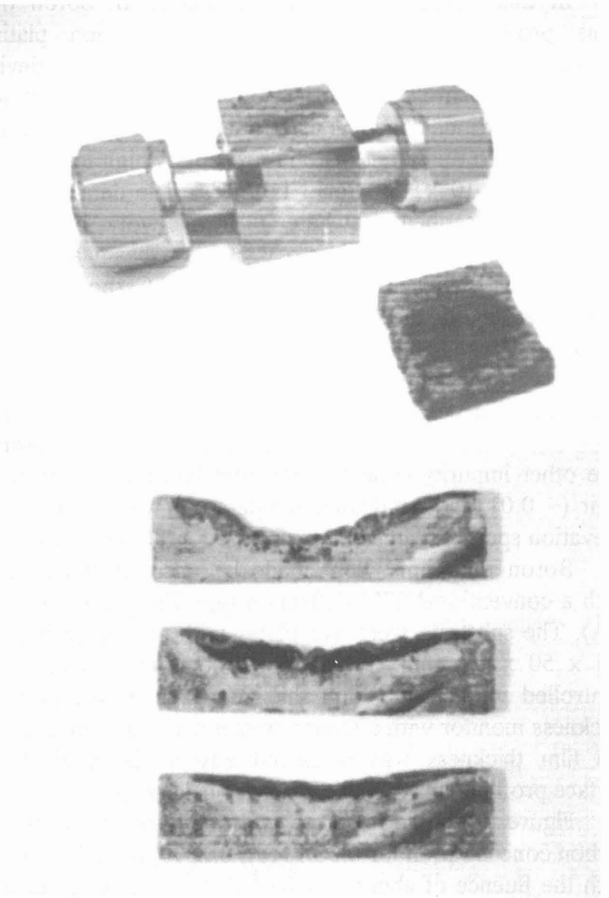

Fig. 1. SiC/SiC composite divertor model specimen after heat load tests.

Reference

[1] Imamura, Y., Oku, T., Kurumada, A., Tomota, Y., et al., Proceedings of 1999 US-Japan Workshop (99FT-05), New Mexico, USA, (1999.11.1-4), VIII 23-27.

[2] Kurumada, A., Imamura, Y., Tomota, Y., Oku, T., et al., J. of Nuclear Materials, 313-316 (2003) 245-249.