

§45. Heat Load Test of Divertor Plate Module of LHD

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Carbon-copper joint materials has been developed as high heat flux components for the diverter plate of Large Herical Device(LHD) that is being constructed at NIFS. The main aims of this study are to estimate (1) resistance of joint layer for repeated heat load, (2) erosion of carbon materials and (3) mechanism of impurity emission due to erosion.

The allowable baking temperature of the vacuum chamber of this device is limited to around 100 °C by the technical requirement. For the lower-temperature baking, it is important to effectively reduced oxygen impurity. It is planning to use B contained carbon materials for the surface materials of the diverter plate due to the oxygen gettering effect of B but the thermal conductivity of the B contended materials is low. In the present study of this year, heat loading test of B₄C coated carbon materials was carried out to evaluate the high heat load resistance.

The test samples were high thermal conductive carbon-carbon composite(C/C) and B₄C coated C/C produced by chemical vapor reaction that were fabricated at Toyo Tanso Co. Lid. The sample size was 20 mm x 20 mm x 10 mm. The thickness of B₄C layer was about 0.2 mm. The samples were exposed to electron beam in an electron beam facility named the Active Cooling Teststand(ACT) in NIFS. The heat loading time was 30 sec and the energy of electron beam was 30 keV. The samples were placed on block actively cooled with water. The top surface of sample(20 mm x 20 mm) was irradiated almost uniformly by electron beam. During the irradiation, the surface temperature was measured by a pyrometer and time evolution of vacuum pressure and electric current were monitored. Emitted gases and

atoms from the heated specimen surface were also monitored by a quadrupole mass spectrometer(QMS). In addition, surface morphology before and after the irradiation was observed by a scanning electron microscope (SEM).

In the case of C/C, the vacuum pressure started to increase at the same time as the irradiation started and was almost constant during the irradiation. Degradation of the pressure at the second irradiation was about half that of the first time. The QMS measurement showed that m/e=2(H₂O), 28(CO), 44(CO₂) and 15, 16, 27, 29(C_nH_m) increased during the irradiation. The signal of m/e=18(H₂O) decreased and that of m/e=2(H₂), 28(CO) increased exceeding the surface temperature of about 700 °C. This result indicates that chemical reaction $C + H_2O \rightarrow CO + H_2$ occurred at the heated specimen surface. Observation of the surface using SEM showed that no noticeable modification occurred at the peak surface temperature of 1600 °C(3 MW/m²). At the peak surface temperature of 2200 °C, fine cracks were formed. Carbon fibers preferentially eroded and thermal decomposition carbon around the carbon fibers remained at the peak temperature of 2500 °C.

On the other hand, in the case of B₄C coated C/C, an abrupt increase of the pressure occurred in the middle time during the irradiation. After the second irradiation, the large peak of pressure was not detected. The QMS measurement indicated that sublimation of B and emission of gases such as m/e=28(CO, C₂H₄) corresponded to the time evolution of the pressure. When the surface peak temperature was 1600 °C (3 MW/m²), no noticeable modification occurred but the color of the surface turned to be black. This must be due to the loss of B content due to sublimation of B. Local area of the surface was melted and resolidified at the peak temperature of 2050 °C(4MW/m²).Most of B₄C coated layer eroded and carbon fiber appeared at the peak surface temperature of 2400 °C(6 MW/m²). The flake structure was deposited on the surface.

These results indicate that it is necessary to improve gas emission property of the B₄C coated C/C for the high heat load.