§23. Stability of Advanced Tungsten - SiC/SiC Plate under Plasma Exposure in LHD

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R&D and technology integration of high performance materials for plasma facing components (PFCs) and first wall are inevitable for the early realization of fusion reactor. Tungsten (W) is becoming a prime candidate as armor material for protecting high heat flux and suppressing plasma contamination. Although ITER is preparing to use W divertor, many issues are still remaining. The application of SiC/SiC composites to divertor as a substrate to W will be a potential solution to current W divertor concepts. SiC/SiC fabricated by Nano-Infiltration and Transient Eutectic phase (NITE) method has various advantages (low cost, high shape and size flexibility, etc.). In addition, small mismatch in coefficient of thermal expansion between W and SiC is a great advantage in configuring the divertor system. This report provides the high performance HHFC materials R & D status and the plasma exposure test results from LHD.

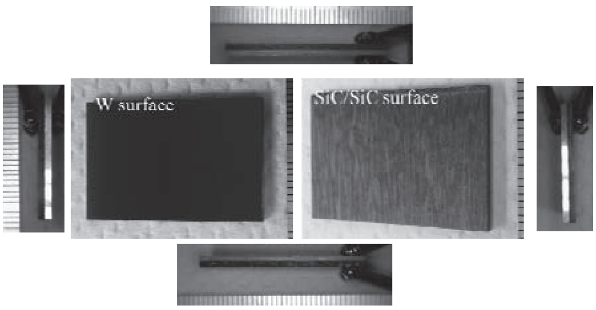

Figure 1. Test samples before Plasma Exposure

W-SiC/SiC dual plate was fabricated by hot pressing, where sample was W plate bonded on NITE-SiC/SiC plate. The plate for the plasma exposure test, with the dimension of 30 x 20 x 2 mm^3 was shown in Figure 1. The thickness of W and SiC/SiC was the same with 1.0 mm. The test samples fabricated were mounted on a carbon stand by molybdenum plate and bolt. The test port for plasma exposure was the port number 10.5L of LHD. The shot number was #121947.

The plasma exposure data are; the maximum applied heat flux ≈ 3 MW/m^2, neutral beam injection (NBI) ≈ 4.9 MW, plasma density ≈ 1.5 x 10^{18} $ions/m^3$, the peak plasma stored energy ≈ 760 KJ, and shot length = 7 seconds.

Figure 2 shows the results of the plasma exposure test. Many clear traces of run-away electrons and melted regions on the W surface (plasma exposure side) can be identified along the plasma strike point indicated by the red dashed lines. In addition, from the side views

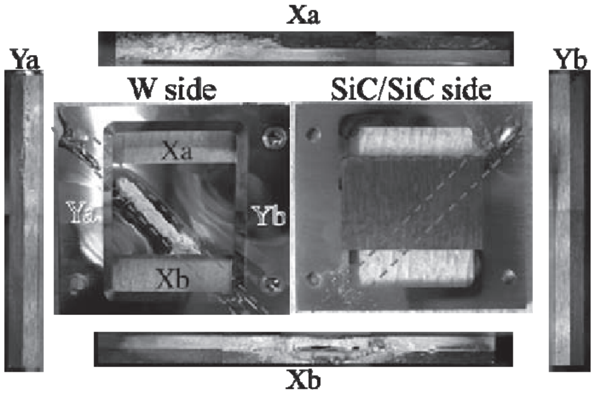

Figure 2. Surface Morphology after Plasma Exposure

of the plates, the melted regions on W surface are recognized to be through thickness melting with gap formation at W-SiC/SiC. However, no significant damage was observed in SiC/SiC side, and the bonding between W and SiC/SiC was damaged only near the melted zone and no crack propagation along interface was observed.

The result of ultrasonic test is shown in Figure 3. The blue area indicates damaged region of bonding interface and yellow area is with no significant damage along bonding interface by the plasma exposure. The blue area with the width of about 14mm is expanding from the plasma exposure area.

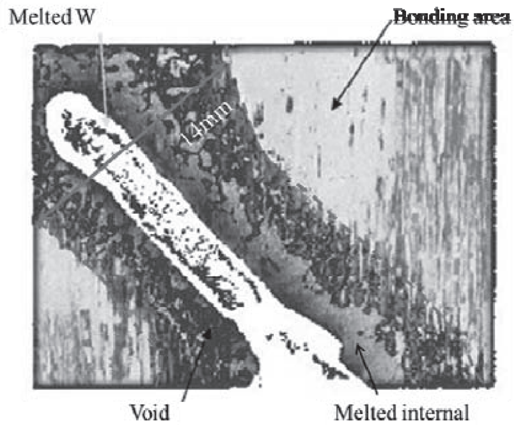

Figure 3. The Result of Ultrasonic Test

The result from the divertor material performance evaluation test in LHD with 3 MW/m^2 heat load plasma exposure test without cooling the W-SiC/SiC was confirmed good resistance. Mechanical property measurement and microstructure analysis are on-going. As the conclusion, excellent potentiality and attractiveness of W-SiC/SiC plate as PFC material was presented by the plasma exposure test at LHD. Additional plasma exposure tests with cooling and appropriate model configuration of divertor with higher heat flux and longer exposure time should be done systematically for the next step. This results will be analyzed with the previous plasma exposure test with 10MW/m^2 .