§41. Behavior of W-SiC/SiC Dual Layer Tiles under LHD Plasma Exposure

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Toward the early realization of Fusion Power Reactors, high performance first wall and plasma facing components (PFCs) are essentially required. As one of the biggest challenges for this, high heat flux component (HHFC) design and R & D has been emphasized [1-3].This report provides the high performance HHFC materials R & D status and the first plasma exposure test result from LHD. W-SiC/SiC dual layer tiles (hereafter, W-SiC/SiC) were developed by NITE Process. This is the new and realistic concept of tungsten armor with ceramic composite substrate for fusion power reactors. The dual layer tiles tested survived under the LHD Divertor plasma exposure (10 MW/m^2 maximum heat load for a 6 second operation cycle). The microstructure evolution, including crack and pore formations, was analyzed and the excellent high heat load resistance is demonstrated.

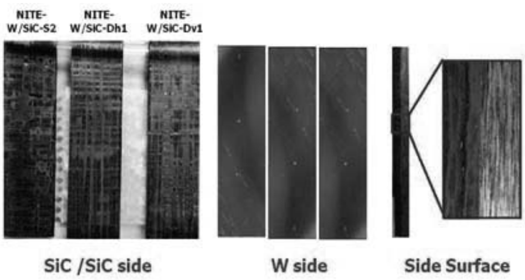

Fig.1. Test Samples before Plasma Exposure

Three types of W-SiC/SiC were fabricated by hot pressing, where ***NITE-W/SiC-S2*** sample was fabricated with pure tungsten powders and SiC/SiC preform with single process. ***NITE-W/SiC-Dh1*** and ***NITE-W/SiC-Dv1*** samples were W plate bonded on SiC/SiC plate with W rolling direction horizontal or vertical to the plate surface, respectively. The tiles for the plasma exposure test, with the dimension of 30x10x1.5 mm^3 are shown in **Fig 1.** Plasma exposure data shows that the maximum applied heat flux ≈10 MW/m^2, neutral beam injection (NBI)≈27 MW, plasma density ≈ 10^{19} ions/m^3,where, plasma stored energy ≈ 1150 KJ, radiation power ≈3000 KW.

After the plasma exposure test, the test samples showed no significant damages. The surface morphology after the test is shown in Fig.2, Fig.3 and Fig. 4, where small fused zone and traces of running electrons on the tungsten surface (plasma exposure side), no detectable damage on SiC/SiC surface, fused zone in W plate and some cavity formations along W-SiC/SiC bonding line are clearly observed. For the case of ***NITE-W/SiC-S2*** sample, fused zones in W plate are not likely as through thickness fused zone, whereas for the case of ***NITE-W/SiC-Dh1,*** through thickness fused zone can be observed. Although on the SiC/SiC surface small cracks along fiber direction were observed, the origins of these cracks are still unclear and to be clarified.

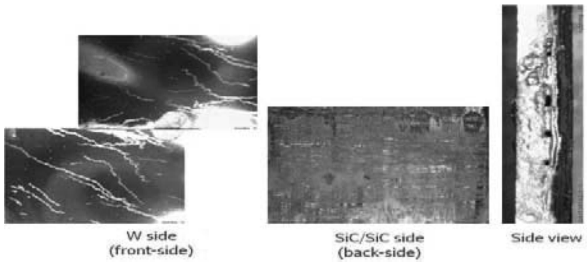

Fig. 2. Surface Morphology after Plasma Exposure (NITE-W/SiC-S2)

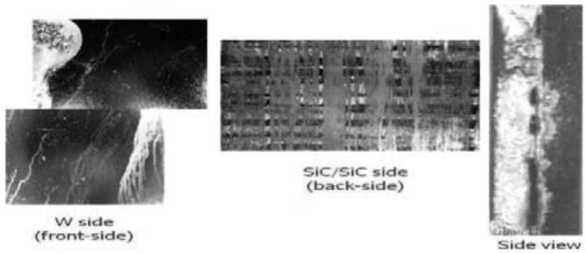

Fig.3. Surface Morphology after Plasma Exposure (NITE-W/SiC-Dh1)

NITE-W/SiC-Dv1sample was made with two W plates, simply due to the sample availability, thus at the center there is a small gap between two W plates. As shown in Fig.4, small fused zones connecting the gap between the two W plates were observed. However, no other clear fused zones neither traces of running electrons were identified. From the side view of the sample, short through thickness direction cracks were observed but no through thickness cracks was detected.

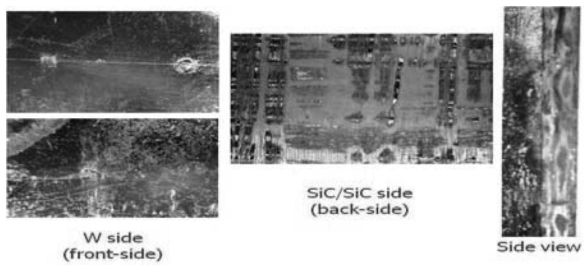

Fig.4. Surface Morphology after Plasma Exposure (NITE-W/SiC-DV1)

The preliminary results from the 1st new divertor material performance evaluation test in Large Helical Device (LHD), with 10 MW/m^2 maximum heat load plasma exposure; excellent resistance to divertor plasma exposure without cooling was confirmed for the three types of materials tested. Material characteristics depending performance evaluation is still underway, however, the potentiality and attractiveness of the W-SiC/SiC dual layer tiles as PFCs are clearly presented. More precisely designed plasma exposure test under LHD may open the reality of the W-SiC/SiC PFC as the most attractive option for the fusion power reactor even as near term option. For this, stronger and extensive efforts will be continued.

[1]P. Norajitra, et al., Fusion Engineering and Design 83(2008) 893-902.
[2]S. Malang, et al., Fusion Engineering and Design 61-62 (2002)295-306.
[3]R. Neu et al., Nuclear Materials, 367-370(2007)1497-1502.