§1. Adaptability Evaluation of Advanced Tungsten Coated Ceramic Materials Using Plasma Exposure Environment 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 protecting high heat flux and suppressing plasma contamination. Although W divertor is considered to use at ITER, many issues are still remained. Joining technology R&D of the W coated SiC/SiC or graphite for high heat flux component is ongoing at OASIS. The application of SiC/SiC composites as a substrate for W will be a potential solution to current W divertor concepts. SiC/SiC composites fabricated by Nano-Infiltration and Transient Eutectic phase (NITE) method have various advantages (low cost, high shape and size flexibility, etc.). In addition, a low CTE (coefficient of thermal expansion) mismatch between W and SiC is a great advantage in configuring the divertor system. Graphite is also one of selectable options for substrate materials, because of its matured fabrication technology and an abundant experimental database. This report provides R & D status and the plasma exposure test results using LHD of the high performance HHFC materials.

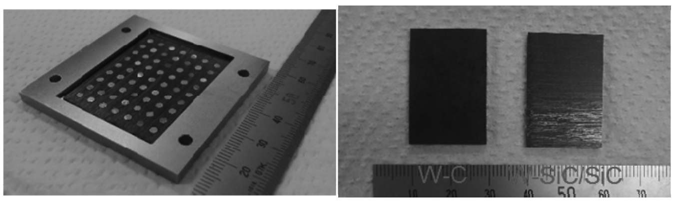

Figure 1. The SiC/SiC insert plate for temperature measurement and the back side appearance of W-coated SiC/SiC and C plate

W-SiC/SiC plate and W-C plate were fabricated by hot pressing, where samples were W plate bonded on NITE-SiC/SiC plate or graphite plate. The backside of plates 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 was 1.5 mm and SiC/SiC or graphite was 0.5mm. In addition, copper (Cu) and aluminum (Al) have been embedded in SiC / SiC insert plate with holes for temperature measurement at the time of plasma exposure. The prepared test samples were mounted on the carbon stand with molybdenum plate and bolt. The SiC/SiC insert plate put in between test samples and carbon stand. The test port for plasma exposure was the port number 10.5L of LHD. The shot number was #125284.

Figure 2 shows the appearance of specimens after the plasma exposure test. Diagonal narrow melted region, indicated by the red line at Figure 2, is plasma strike area. Mo holder is also damaged by plasma. The melted Al can be confirmed from the back side of the W-SiC/SiC and W-C located at plasma strike area.

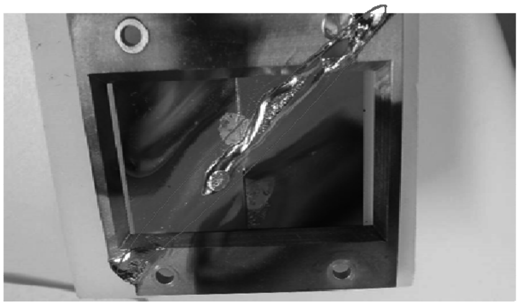

Figure 2. The appearance of W-C and W-SiC/SiC samples after plasma exposure test

However, no significant damage was observed in SiC/SiC and graphite side. The bonding between W and SiC/SiC or graphite were damaged only near the melted zone, but crack propagation along interface cannot be observed.

Figure 3 shows the schematic image of embedded copper and aluminum put in SiC/SiC plate with holes after exposure test. The orange circle means the melted Al or Cu during the exposure test and the red elliptical line means plasma strike area. It was confirmed that the Cu and Al of W-C side melted in a wide range. This is due to the higher thermal conductivity of graphite compared to those of SiC/SiC. It can be estimated that the maximum temperature at the backside of W-SiC/SiC was in the range from 660 ^{o}C to 1080 ^{o}C, and the maximum temperature at the backside of W-C was 1080 ^{o}C or higher.

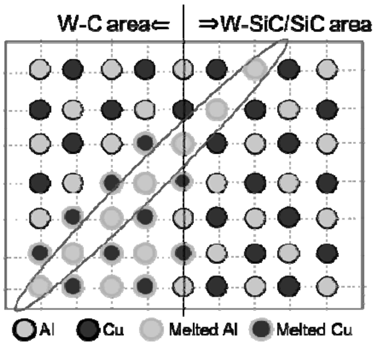

Figure 3. Schematic image of Cu and Al embedded SiC/SiC insert plate after plasma exposure

As the conclusion, excellent potentiality and attractiveness of W-SiC/SiC W-C plates as PFC material were presented by the plasma exposure test at LHD. It was confirmed the superior durability of W-SiC/SiC and W-C form the plasma exposure test without cooling. Mechanical property measurement and microstructural analysis are on-going. For next step, it will be required the integrated plasma exposure test and the appropriate model configuration of divertor based on these experimental results.