§ 6. Behavior of Rhenium Interface on Tungsten Coated Carbon by Heat Load

Tokunaga, K., Tamura, S., Miyamoto, Y., Fujiwara, T., Yoshida, N. (Res. Inst. Appl. Mech. Kyushu Univ.)
Sogabe, T. (Toyo Tanso Co., Ltd.)
Kato, T. (Nippon Plansee K.K.)
Schedler, B. (Plansee Aktiengesellschaft)
Kubota, Y., Noda, N.

Divertor plate of LHD will be subjected to high heat and plasma particles with a low energy and a high flux. Tungsten seems a promising candidate material for surface material of the divertor plate because of its low sputtering yield and good thermal properties. Disadvantages of tungsten as a plasma facing material are its heavy weight and poor workability. One of the possibilities to overcome them is to coat tungsten on light carbon materials, which have shown good heat load resistance in the present plasma confinement devices. However, tungsten forms tungsten carbide and brittle carbide is produced at high temperature during use.1) Exfoliation may occur on the joint interface of tungsten and carbon tile due to the brittle carbide formation. It is known that Re is effective for carbon diffusion barrier to tungsten layer and suppress formation of the brittle tungsten carbide. The purpose of the present study is investigate structure change of Re interface in order to optimize thickness and structure of Re between the carbon tile and tungsten.

Tungsten coating (VPS-W) on CFC (CX-2002U) with a Re/W multilayer interface was made by vacuum plasma spraying(VPS), then heat treatment was performed to stabilize the microstructure of the coating materials. The coated W is 0.5 mm thick and about 92.5% dense. Experimental samples have sizes of 10×10×5 mm. Some of the samples were polished to get flat surface. The samples were set in the vacuum chamber of the electron beam facility and degassed in vacuum at 700 °C for half an hour. After then the samples were heated by focusing 20 keV electron beam on the cross section of VPS-W/CFC. The beam heated not only the cross-section of tungsten coating but also some part of the declined tungsten surface. The surface temperatures were measured with an optical pyrometer. After the annealing, the cross sections of the samples were mechanically polished carefully and chemically etched, and then their microstructure, compositions and grain sizes were measured.

The structure of interface and the VPS-W do not change at 1400 °C for 60 min. This result indicates that the Re/W multilayer acts as a diffusion barrier for carbon and suppress the tungsten carbide formation of the VPS-W layer. However, the Re/W layers disappeared and formed alloys at 1600 °C for 10 min, very hard tungsten carbide layer with a thickness of 15 μm were formed in the VPS-W. A thickness of the tungsten carbide layer in the VPS-W increases with increasing annealing time, however, its thickness changes according to logarithms rule up to 60 min. This suggests that the interface layer alloyed acts as carbon diffusion barrier. A thickness of tungsten carbide at 1800 °C up to 30 min is thicker than that of 1600 °C, but, its thickness changes still according to logarithms rule. On the other hand, at 1800 °C for 60 min, the thickness change of tungsten carbide shits from logarithms rule and depend on parabolic rule.

The thickness of tungsten carbide layer increases and changes according to parabolic rule at 2000 °C for 1 min. It is thought that the interface layer alloyed do not act as carbon diffusion barrier in this temperature.

Fig. 1 shows SEM images of the cross section of VPS-W/CFC, which was annealed at 2000 °C for 30 min. It can be seen that cracks are formed in the tungsten carbide layer. Such kind of crack formation occurs in the tungsten carbide layer, which was formed in the other annealing condition. Repeated heat load tests will be required to investigate the effect of crack formation on thermal behavior and exfoliation.

The next fiscal year, VPS-W/CFC tiles with modified Re/W layer will be fabricated to optimize the interface structure.

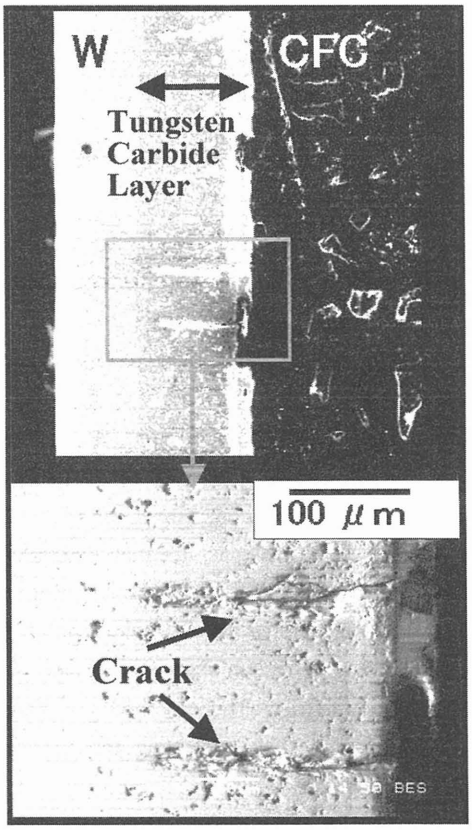

Fig. 1. SEM images of cross section of VPS-W/CFC annealed at 2000 °C for 30 min.

Reference
1) E Lassner and W.-D. Schubert, Tungsten, Plenum Publishers, New York, 1999. p.139.