§26. Development of VPS-W Coated Carbon Materials for LHD Divertor

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Isotropic graphite IG-430U is used for the present divertor tiles of LHD. Performance of plasma is improving year by year by reinforcing heating power and installing new type divertors. However, carbon impurities originating from the divertor tiles increased remarkably since C-15 campaign (2012) and they deposited widely on the plasma facing surfaces. It has been reported that the exfoliation of thick deposition of carbon terminated often long pulse discharges. On the other hand, carbon deposited surface has strong retention of H and He and they desorb in the wide temperature range from room temperature up to above 1000K. It is concerned that large outflux of plasma gas under discharges would make difficult to control particle balance under steady state operation.

In LHD, preliminary test of W coated divertor plates (VPS-W/IG-430U, Plansee Co.) has already started by replacing some graphite divertor plates. Though it has high performance, for examples, no exfoliation even melted and very little influence on plasma performance, its cost is considerably high because the production process is complicated. It would be unrealistic to replace all divertor tiles with this tungsten coated graphite.

In the present work, therefore, it is aimed to develop W coated IG-430U at reasonable cost but satisfies required performance to endure the heat load up to 10 MW/m^2.

Based on the studies so far, VPS-W were deposited on the IG-430U tiles under the following conditions at TOCALO Co., Ltd..

[1] In order to get uniform texture but to minimize the formation of tungsten carbide, the temperature under the VPS process was carefully controlled.

[2] To get uniform texture with less pores, the un-melted and re-solidified powders were suppressed.

Texture of the VPS-W/IG-430U formed under these conditions has following features.

[1] The melted W got well into the crevices at the IG-430U surface, but carbide were hardly formed.

[2] Number of pores decreased but they were still formed.

Cyclic heat load test were performed with ACT/NIFS by changing heating power from 8 to 11 MW/m^2. At each heating power pulse heat load for 20s were repeated 16 times. Fig.1 shows the changes of the substrate temperatures measured at the surface (IR), at the middle of the thickness (TC) and at the surface of heat sink (TC). It was confirmed that the tested sample kept integrity up to 10 MW/m^2 (surface temperature at 1200ºC), but small area at the beam center was melted and a few vertical cracks run from the melted spot. Exfoliation, which was a matter of concern, did not happened. This indicates the bonding between IG-430U and VPS-W and also between layers of W is strong enough. The test samples produced in the present work satisfied the minimum condition for utilization in LHD.

These results indicate that increasing of heat conductivity, namely, decreasing of pores is necessary to improve heat load resistance furthermore. In order to get higher quality VPS-W/IG-430U, second run of the plasma spray were carried out by changing the spray conditions. Analysis of the new samples are now going.

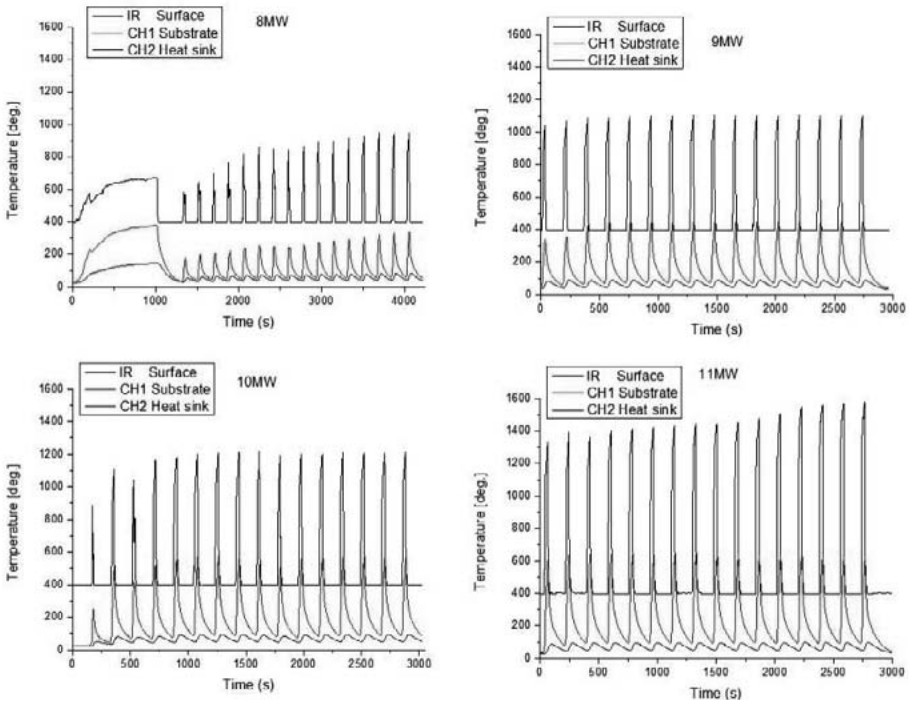

Fig. 1 Temperature changes under cyclic pulse heat load