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Examination of integrity of W/Cu joint interfaces after heat loading at ACT2 by means of an ultrasonic technique

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1. Introduction

Tungsten (W) plasma facing mono-block jointly brazed with a copper (Cu) alloy has been proposed as a divertor together with a cooling system in the tokamak DEMO reactor as well as future helical reactors [1]. For safe usage of them, it is important to understand how a tungsten and copper (W/Cu) joint interface would maintain its integrity after heat loading from plasma-facing W. We have demonstrated application of an ultrasonic technique (UT) to observe damaging processes of the W/Cu joint interface non-destructively after repeated heat-loading at the electron beam device, ACT2, NIFS.

2. Experimental

Cubic-type W/Cu joint samples (30 mm x 30 mm in surface area, W: 3 mm in thickness, Cu: 30 mm in thickness) were manufactured by hot isostatic pressing (HIP) with a typical method using BNi-6 as the filler materials [2]. A hole (0.6 mm x 20 mm) for a thermocouple (TC) was made in the W layer and the Cu layer parallel to the surface to monitor the temperature of the each layer.

Heat-loading was performed at ACT2. The facility parameters, irradiation and cooling scheme has been reported in details elsewhere [3]. During the heat-loading corresponding to approximately 10 MW/m2 flux for the W surface (20 cycles: heating for 30 sec, cooling for 30 sec), it was stopped since a significant increase in the surface temperature of the W layer was observed and a sample holder made of Mo was broken.

Ultrasonic technique has been applied to observe a 2 dimensional distribution of ultrasound reflection wave (C-scan) by using Ultrasonic Flaw Detector & Imaging System SDSIII (10 MHz, 0.75 inch focusing probe), KJTD Co., Ltd.

3. Results and discussion

Figure 1 shows C-Scan image at the W/Cu joint interface in the initial state (left) and after heat-loading (right). An intensity of ultrasonic reflection is higher as a color changes blue (background), yellow to red. One can clearly see the hole for TC in a center part due to lacking of the data at the joint interface. After the heat-loading, some data are missing at two edge corners indicating the joint surface was largely cracked and delaminated as we could confirm visually from the side surface of the sample. In addition, high spots of ultrasound reflection were observed at the joint interface suggesting small cracks or flaws initiated over the joint interface layer. Presumably, the direction of crack formation coincides with the particular direction, e.g. rolling direction of the W layer.

In the presentation, visual inspection data on the side-surface and the cross-sectional surface would be discussed focusing on crack formation after the heat-loading.

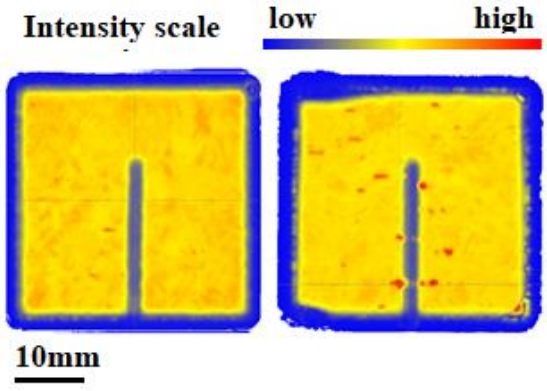

Fig.1. C-Scan image of W/Cu joint sample interfaces in the initial state (left) and after heat-loading (right)

References

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