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タングステンモノブロックの表面損傷が熱負荷応答に与える影響
Effect of surface damage on thermal reaction of tungsten monoblock

田中泰史[1],上田良夫[1],LEE Heun Tae[1],永田正義 [2],菊池祐介[2],鈴木哲[3],関洋治[3]
TANAKA Yasufumi[1], UEDA Yoshio[1], LEE Haun Tae[1], NAGATA Masayoshi[2], KIKUCHI Yusuke[2], SUZUKI Satoshi[3], SEKI Yohji[3]

[1]阪大院工, [2]兵庫県立大学院工, [3]日本原子力研究開発機構
[1]Graduate School of Engineering, Osaka University, [1]Graduate School of Engineering, University of Hyogo, [3]Japan Atomic Energy Agency

1. Introduction

Tungsten (W) monoblock will be used in the divertor of ITER. In the divertor, transient heat loads such as Edge-Localized Mode (ELM) and disruption will be applied in addition to steady-state heat loads and slow transient. Recent investigations have demonstrated that transient heat load gives the surface damage such as melting or cracking on the tungsten surface [1]. In this study, we gave simulated transient heat loads to the W monoblock with the surface damage (melting or cracking) by the electron beam and pulsed plasma to investigate the change of surface structure and heat removal capability of the W monoblocks. From this experiment, the effect of surface damage on thermal response and heat removal performance of W monoblocks were investigated.

2. Experimental

We prepared five W monoblocks and gave surface damage to four monoblocks of them prior to steady-state heat loading. ELM-like heat load (Energy fluence of 0.7MJ/m^2) using plasma gun of University of Hyogo [2] was applied to three tungsten monoblocks with shot numbers of 20, 40, and 100 to make cracks on the surface. Moreover, disruption-like heat load (1GW/m^2, 5msec) using JEBIS (electron beam of JAEA) [3] was given to the monoblock to cause melting on the surface. Finally, repeated heat load using plasma gun (Energy Fluence of 2.0MJ/m^2, 20 times) was given to the last one monoblock to arise melting and cracking on the surface. These five monoblocks were connected to a cooling pipe. Heat load test simulating steady-state heat load (10MW/m^2, 10sec, 300cycle) and slow transient (20MW/ m^2 , 10sec, 300cycle) were performed by JEBIS. The changes of surface structure after electron beam irradiation were observed using laser beam microscopy.

3. Results

After electron beam irradiation, recrystallization (grain size ~50µm) and associated level difference between grains (~10µm) occurred in the monoblock without initial surface damage (Fig.1 E). In contrast, progress of cracking and melting occurred in the monoblocks with the initial cracks (Fig.1 A~D). Moreover, radial crack centered on the melting position by the disruption-like heat load appeared (Fig.1 D). Furthermore, the longitudinal cracks over entire monoblocks appeared in all monoblocks. These cracking of the monoblocks with surface damage (Fig.1 A~D) occurred at 18 cycle or less of 20MW/ m^2 heat loading but cracking of the monoblock without initial surface damage (Fig.1 E) occurred at 101 cycle or later of 20MW/m^2 heat loading. These cracks reached the cooling pipe. Level difference around the longitudinal cracks were observed. In the monoblock melted by pulsed plasma, level difference was about 240µm (Fig.1 C). In addition, around the longitudinal cracks, growth of grain was larger than other part of the monoblock, further, a lot of grain ejection occurred at the monoblock without initial surface damage (Fig.1 E) and irradiated 100 times ELM-like heat load (Fig.1 A). It is considered that there was no change of heat removal performance because during heat load test, the surface temperature was constant.

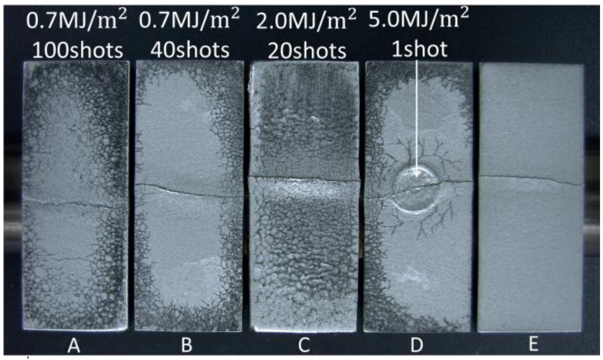

Fig.1 W monoblock after electron beam irradiation

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