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# Effect of surface damage of tungsten on thermal response to pulsed heat
# タングステンの表面損傷がパルス熱負荷応答に与える影響

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In this study, surface damaged tungsten (melting, cracking and recrystallization) by pulsed plasma gun and e-beam were exposed ELM-like heat loads with Nd:YAG laser. The energy fluence of 0.043-0.30MJ/m$^2$ was applied with shot numbers of $10^2$-$10^4$.The surface structure changes after laser irradiation were observed using laser beam microscope. After laser irradiation, the grain ejection occurred above certain energy fluence and its threshold energy fluence was lowered with increasing shot numbers.

## 1. Introduction

Tungsten (W) is a candidate of plasma-facing materials and will be used in the divertor of the ITER. Recent studies have demonstrated that Edge-Localized mode (ELM)-like pulsed heat loads gives the surface damage as melting or cracking on the tungsten surface [1]. Furthermore, it is expected that the recrystallization occurs by slow transient heat load. But the effects of these surface damage on surface erosion are not known well under additional heat loads conditions in ITER. In this study, surface damaged W (melting, cracking and recrystallization) by pulsed plasma gun and e-beam were exposed ELM-like pulse heat loads with Nd:YAG laser to observe more surface erosion or grain ejection. From this experiment, the effect of surface damage on pulse thermal reaction of W were investigated.

## 2. Experiment

We prepared two ITER-grade W (Plansee co.) specimens and gave surface damage. ELM-like heat load using a plasma gun device in University of Hyogo [2] was applied to one W with energy fluence of 0.7MJ/m$^2$, shot numbers of 100 and energy fluence of 1.4MJ/m$^2$, shot numbers of 25 to make cracks on the surface and was applied to another W with energy fluence of 2.0MJ/m$^2$, shot numbers of 25 to cause melting and cracking on the surface. Finally, e-beam simulating the steady-state heat load (10MW/m$^2$, 10sec, 300 cycles) and the slow transient (20MW/m$^2$, 10sec, 300cycles) were applied to both W by JEBIS (electron beam of JAEA) [3] to cause recrystallization (grain size ~40μm) on the surface. The heat load tests simulating ELM-like heat loads were performed by Nd:YAG laser in the vacuum of ~$10^{-7}$torr. The energy fluence of 0.043-0.30MJ/m$^2$ was applied with shot numbers of $10^2$-$10^4$.The beam diameter was 0.6mm and pulse width was 0.3ms. The initial temperature of the specimens was 773 K. The surface structure changes after the heat load test were observed using laser beam microscopy.

## 3. Results

After laser irradiation, on damaged W-1 (cracking and recrystallization), grain ejection occurred above certain energy fluence each shot numbers. Its threshold energy fluence was 0.26 MJ/m$^2$, 0.21 MJ/m$^2$ and 0.087 MJ/m$^2$, respectively in the shot numbers of $10^2$, $10^3$, $10^4$ . This result indicate that the threshold energy fluence was lowered with increasing shot numbers. Laser beam microscope image of grain ejection at energy fluence of 0.21MJ/m$^2$ with shot number of $10^3$ are shown in Fig.1. As illustrated in Fig.1, the diameter of ejected grain was about 40 μm and grain ejection occurred around cracking.

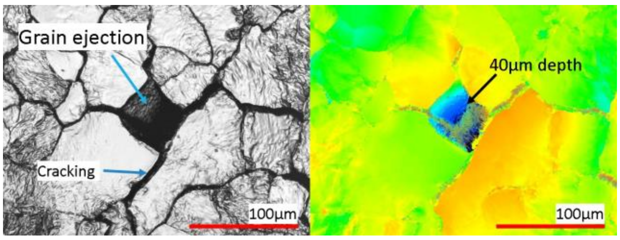


Fig.1. Grain ejection on damaged W-1

On the other hand, on damaged W-2 (cracking, melting and recrystallization), grain ejection only occurred at shot numbers of $10^4$. The grain ejection on W-2 at energy fluence of 0.30MJ/$m^2$ with shot number of $10^4$ is shown in Fig.2. Fig.2 shows that grain ejection of very large size compared with one of W-1 occurred.

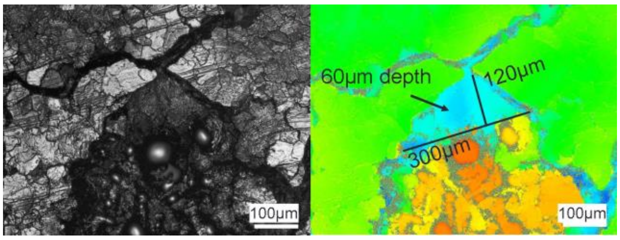


Fig.2. Grain ejection on damaged W-2

**References**

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