27pB11

TFGRタングステンへの短パルス繰り返しレーザー照射影響
Effects of repeated short pulse laser effects on TFGR-W

上田良夫[1]、河合俊昇[1]、阪本雄祐[1]、大塚裕介[1]、栗下裕明[2]、木村晃彦[3]、吉田直亮[4]
UEDA Yoshio[1], KAWAI Toshitaka[1], SAKAMOTO Yusuke[1], OHTSUKA Yusuke[1], KURISHITA Hiroaki[1], KIMURA Akihiko[1], YOSHIDA Naoaki[1]

大阪大学、東北大学、京都大学、九州大学
Osaka University[1], Tohoku University[2], Kyoto University[3], Kyushu University[4]

Introduction

Tungsten as plasma facing materials of fusion reactors is principally a brittle material. Low temperature, recrystallization, and neutron irradiation embrittlement is a matter of concern. To overcome this difficulty, tungsten materials development is in progress. Among these, TFGR W (Toughened, Fine Grained, Recrystallized tungsten) shows excellent features in terms of low temperature embrittlement (DBTT (Ductile Brittle Transition Temperature) is around RT) and recrystallization embattlement. Its responses to edge plasma exposure, however, have not been evaluated much. In order to understand the behavior of TFGR-W in edge plasma environments, D retention under high flux plasma conditions, melting behavior in tokamak edge plasmas (TEXTOR tokamak, FZJ) and cracking behavior by high cycle pulsed loads have been studied. In this presentation, response to high cycle pulsed heat loads will be shown.

Experimental

Specimens used for this study were TFGR-W doped with 1.1wt% of TiC or 3.3wt% of TaC dispersoids. Details of fabrication and material properties are shown in Ref. [1]. Pulsed heat irradiation was made by a Nd/YAG pulse laser. Energy fluence was changed up to 1.22 MJ/m^2 with effective pulse length of 130 μm (long pulse mode). Initial temperature of specimens was 773 K. Energy absorption rate of TFGR-W was 27-28%, similar to that of pure W (~30%). For even the highest pulse energy fluence case (1.22 MW/m^2), surface temperature was still below a melting point of tungsten (3695 K). After laser pulse irradiation, surface morphology was measured by SEM. Microstructure beneath surfaces of specimens was observed by TEM.

Results

Both TFGR-W showed surface roughness even under low energy fluence conditions (0.49 MJ/m2), which was roughly 1/3 of melting threshold. As energy fluence increased, cracking appeared. For TFGR W 3.3TaC roughening appeared at slightly lower energy fluence and showed finer cracking pattern. For TFGR-W 1.1TiC, surface morphology was similar (with slightly rough crack pattern).

Microstructure, however, was quite different for these TFGR-W at the highest energy fluence case (1.22 MJ/m^2). For TFGR-W 3.3TaC, grain sizes are similar to those without pulse irradiation. On the other hand, significant grain growth was observed for TFGR-W 1.1TiC. This difference could be attributed to the stability of dispersoids at elevated temperature. For 1.22 MJ/m^2, surface temperature reached about 2900 K and TiC dispersoids disappeared, which enhanced grain growth, see bottom figure (left column) in Fig. 1. But TaC dispersoids could still remain even at this temperature, which suppressed grain growth see bottom figure (right column) in Fig. 1.

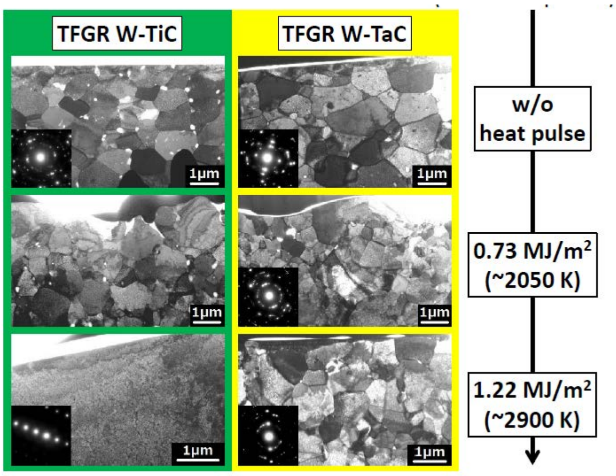

Fig.1 Near-surface microstructure after 10,000 pulses for TFGR 1.1TiC and 3.3TaC.

[1] H. Kurishita et al. J. Nucl. Mater. 398, 87–92 (2010) 87–92