SURFACE MODIFICATION AND EROSION ON TUNGSTEN MATERIALS BY PULSE HIGH HEAT LOADING

K. Tokunaga[1], T. Fujiwara[1], K. Araki[1], Y. Miyamoto[1], K. Nakamura[1],
H. Kurishita[2], K. Ezato[3], S. Suzuki[3], K. Yokoyama[3], Y. Seki, M. Enoeda[3] and M. Akiba[3]

[1]*Research Institute for Applied Mechanics, Kyushu University, Kasuga, Fukuoka 816-8580, Japan*
[2] *International Research Center for Nuclear Materials Science, Institute for Materials Research (IMR), Tohoku University, Oarai, Ibaraki 311-1313, Japan*
[3]*Japan Atomic Energy Agency, Naka, Ibaraki 311-0193, Japan*

Corresponding author:tokunaga@riam.kyushu-u.ac.jp

Tungsten materials are potential candidates of the divertor and the first wall/blanket armor materials of the demo reactor due to their very low erosion yield and high temperature properties. However, they exhibit serious embrittlement in several regimes, i.e., low temperature embrittlement, recrystallization embrittlement and radiation embrittlement. To overcome these problems, newly-developed tungsten materials have been proposed. However, the characteristic of disruption and ELM erosion and damage of these materials have been unclear. In the present work, pulse high heat loading experiments have been performed in order to investigate the disruption and the ELM erosion and damage characteristics of these tungsten materials.

Tungsten samples used in the present experiment are powder metallurgy tungsten(PM-W) with rolling direction of parallel and perpendicular for the surface, La_2O_3(0.96wt%) doped W, K(0.003wt%) doped W, ultra-fine grained (UFG) W-0.5wt%TiC with Mechanical Alloying (MA) in H_2 atmosphere(W-0.5wt%TiC/H) and UFG W-0.5wt%TiC/Ar with MA in Ar atmosphere(W-0.5wt%TiC/Ar). Both UFG W-0.5wt%TiC compacts are in the as-HIPed condition, and not plastically formed for ductility enhancement. The sample sizes are 10mm x 10mm x 1mm. The samples have been exposed to pulse heat loading by electron beam irradiation using an Electron Beam Irradiation Stand (JEBIS) at JAEA. The heat flux is 1 GW/m^2, with duration of 0.6 ms. The half width value of the electron beam was 8 mm. The electron beam area on the tungsten surface is defined by a beam limiter with an aperture of 4 mm. The electron beam energy is 65 keV, and the heat flux was measured by the calorimetric method. The temperature of the sample on the side opposite to the electron beam irradiation is measured a thermocouple. The sample surfaces after the electron beam irradiation have been examined using a scanning electron microscope (SEM). Weight loss of the samples has been also measured with an electronic balance.

After the electron beam irradiation, a footprint of the molten and resolidified surface can be observed. The footprint of the splashing of the molten layer is observed on La_2O_3 doped W and W-0.5wt%TiC/Ar whereas relatively smooth surface is observed on PM-W, K doped W and W-0.5wt%TiC/H_2. The electronic balance measurement showed that weight loss of La_2O_3 doped W and W-0.5wt%TiC/Ar due to the heat loading was more than ten times larger than that of PM-W, K doped W and W-0.5wt%TiC/H_2. The large weight loss is considered to be the splashing of the molten layer. One of the reason of the splashing of molted layer is considered to be caused by boiling of La_2O_3 and Ar bubble of La_2O_3 doped W and W-0.5wt%TiC/Ar, respectively. The present experiments indicated that K doped W and W-0.5wt%TiC/H_2 are promising tungsten materials, where disruption and ELM heat loading is exposed.