§5. Observation of Tungsten Droplet Splashing by Pulsed High Heat Load Irradiation by using the SPICA Plasma Gun Facility

Nagata, M., Ikeda, T., Yagi, I., Fukumoto, Y.N. (Univ. Hyogo),
Miyazawa, J., Tokitani, M., Masuzaki, S., Yamada, H.

The transient high-heat flux can generate melt-layer formation of tungsten (W), melt motion and droplet ejection, leading to surface erosion of plasma facing components (PFCs) and serious contamination in plasmas which become major concerns in large fusion devices such as ITER[1]. Recently, modeling and computational studies of the physical mechanisms involved in splashing and formation of droplets have been performed[2,3], but detailed comparisons with experiments are required to understand physical process of macroscopic melt droplet formation under ELMs. Although the tungsten melt-layer motion were analyzed under tokamak conditions at TEXTOR[4], transient W melting experiments using plasma gun facilities do not include the imposed magnetic field on the target[5]. This paper will present the experimental study of dynamics of W droplet splashing with including the effect of the magnetic field which was carried out in the magnetized coaxial plasma gun SPICA facility at NIFS.

In the experiment, we demonstrated the melt layer erosion and splashing on two W target plates installed with a difference in level in a chamber. These phenomena were observed under the condition of ITER-ELM relevant heat loads of 1.9 MJ/m^2. Note that the W surface temperature increases rapidly to the melting temperature of 3695 K within the plasma pulse duration of 0.12ms. The peak gun current is 200-300 kA at the charging voltage of 15-23 kV. The velocity of hydrogen plasma stream is 120-160 km/s. The electron density of plasma is 2x10^{21} m^{-3}. The angle between the target surface and the plasma stream is set to 45 degree. There are traces of coagulation of meting W and bridging of gaps due to melt motion on the damaged area (30x40 mm). We identified droplets emitted from the W target surface by using a high speed camera. The droplets are ejected in the parallel direction to the plasma stream. The moving of droplets can be seen for t=1.5 ms after the plasma impact terminates at t=0.12 ms. The droplet continues to be ejected from the melt layer after the impact. The droplet speed is about 26 m/s at t= 0.3 ms and then slows down to 13 m/s at t=1 ms. The $\boldsymbol{J}$x$\boldsymbol{B}$ pinch force produces the droplet ejection of the melt layer due to the plasma pressure.

We have applied externally the magnetic field $B_{\rm ext}$ < 0.15 T parallel to the direction of plasma stream. Figure 1 shows the time evolution of the number of W droplets in variation of the $B_{\rm ext}$. Figure 2 shows that the magnetic field could decrease the droplet speed and suppress completely the droplet splashing as $B_{\rm ext}$ increases. Also, the suppression efficiency depends on the direction of the parallel magnetic field. According to the simulation of droplet splashing caused by Kelvin-Helmholtz instability[3], we could explain that the propagation of surface waves is damped by the imposed magnetic field parallel to the W-melt flow if there is no the plasma stream, so resulting in suppression effects on the development of droplets.

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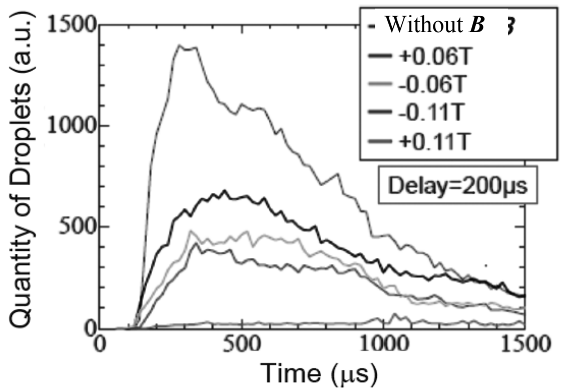

Fig. 1. Time evolution of quantify of W droplets in variation of the eternal magnetic field strength.

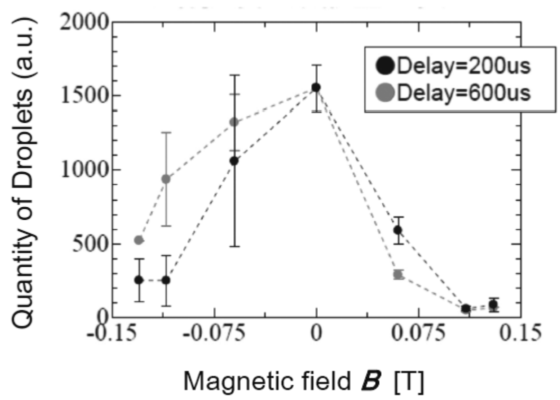

Fig. 2. Quantify of W droplets as a function of the eternal magnetic field strength in each direction.