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Dynamics and control of droplet splashing from tungsten divertor materials generated by ELM-like heat loads

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The ELM-like transient high-heat flux generates melt-layer formation of tungsten (W), melt motion and droplet ejection, leading to surface erosion of plasma facing components in large fusion devices such as ITER. This paper will present the experimental investigations of dynamics of W droplet splashing with including the stabilization effects of the magnetic field, which have been performed by using the magnetized coaxial plasma gun SPICA facility at NIFS.
In the experiment, we have 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 2˜4 MJ/mˆ2. The surface temperature measurement indicates that the W surface temperature increases rapidly up 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 2x10ˆ21 mˆ-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 JxB pinch force produces the droplet ejection of the melt layer due to the plasma pressure.
We have applied externally the magnetic field B < 0.15 T parallel to the direction of plasma stream. It has been found that the magnetic field could decrease the droplet speed and suppress completely the droplet splashing as B increases. Also, the suppression efficiency depends on the direction of the parallel magnetic field. One possible explanation is that the propagation of surface waves such as Kelvin-Helmholtz instability is damped by the imposed magnetic field parallel to the W-melt flow and the plasma stream near the surface, so resulting in suppression effects on the development of droplets.

Eligible for student paper award?

No

Authors: Dr NAGATA, M (University of Hyogo); FUKUMOTO, N (University of Hyogo); Mr IKEDA, T (University of Hyogo); Dr MIYAZAWA, J (National Institute for Fusion Science)

Presenter: Dr NAGATA, M (University of Hyogo)

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