Investigation of Microparticles emission DURING A PULSE HEAT LOAD on BETA facility

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One of the remaining tasks of the ITER project is the problem of erosion of the first wall and the divertor due to interaction with plasma. Compared to existing devices for magnetic plasma confinement, the ITER tokamak will have a longer discharge time and much larger heat flux to plasma-facing components. Moreover, during the ITER experimental campaign, intense transient plasma fluxes on the surface of the divertor cannot be excluded. In these cases, the erosion of the material will increase significantly; a molten layer will appear on the surface, from which the emission of microparticles is possible.

Microparticles can penetrate into the plasma center and cause a significant increase in radiation loss, which in turn can lead to problems with plasma confinement. In addition, the accumulation of a large number of microparticles in a vacuum vessel will lead to the retention of large amount of tritium, which is limited by radiation safety requirements [1].

This paper presents the results of experimental simulation of the impact of high-power pulsed thermal loads on the surface of tungsten. A high power submillisecond electron beam (10 MW, up to 300 μs) is employed for experimental simulation, it allows to create a heat flux with a power density of up to 20 GW/m2 in area of about 1 cm2. The experiments use a number of optical diagnostics to determine the parameters of microparticles and gas emitted from the target surface.

Multi-angle fast imaging allows determining the speed of microparticles, the time and place of their ejection. The particle velocity measured by this method can reach several hundred m/s. It was found that the length of the microparticle tracks linearly depends on the distance to the surface, which can be explained by nearly simultaneous ejection of microparticles from the surface of the sample. The places of ejection of microparticles correspond to features on the surface, such as the edges of cracks and areas with elevated temperature.

Small-angle laser scattering makes it possible to determine the size of particles inside a laser beam that running parallel to the surface a few millimeters from it. Analysis of the signals of scattered radiation shows that small particles (2 μm) have a greater speed and reach the laser beam before large ones (8 μm). The intensity of the scattered radiation and, consequently, the number of microparticles grows rapidly with the increasing heat flux parameter above 180 ± 15 MJ m–2s–0.5.

References

1. In-vessel dust and tritium control strategy in ITER, Journal of Nuclear Materials 438, <https://doi.org/10.1016/j.jnucmat.2013.01.217>.