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Status of Studies of Pulsed Heat Load Influence on Tungsten at BETA Facility and Station of SR Scattering ”Plasma” in BINP

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Experiments simulating the pulsed heat loads expected in the ITER divertor were carried out at the BETA facility in the Budker Institute. Using a pulsed electron beam with a duration of 0.2-0.3 ms and heat load with a heat flux factor HFF ≈ 30 MJ m-2s-0.5 below the melting point of tungsten were obtained. A distinctive feature of BETA is the ability to study the processes of erosion of tungsten in situ during the heating and immediately after it in the cooling stage. This ability is provided by optical diagnostic methods, using the thermal radiation of the surface and illumination by a continuous laser. The obtained data make it possible to study the dynamics of the temperature distribution on the target surface and the development of its erosion in time. The image of the target surface in its own thermal radiation shows that even under a homogeneous electron beam, having a Gaussian profile with a full width at a half maximum of about 17 mm, hot spots are visible with a temperature much higher than the temperature of the surrounding area. Analysis with SEM and microsections shows that overheating is associated with a decrease in heat removal from these surface areas due to cracks caused by pulsed heating. The method of laser illumination reveals a two-stage process of erosion of the polished tungsten surface after the first heat load. Initially, the surface roughness begins to increase, reaching a maximum at the end of the heating pulse, and then decreases within a few milliseconds upon cooling to a value 2-3 times higher than the initial level of roughness. The second stage of surface modification, corresponding to surface cracking, occurs spontaneously and rapidly develops for a time of the order of ten microseconds on a sample already cooled to room temperature. The delay in the initiation of cracking of the surface exceeded the time required for the transition from the plastic to the brittle state by 3-4 orders of magnitude.
Synchrotron radiation scattering station “Plasma” develops diagnostics of deformations and stresses in the material under the pulse heat load using the diffraction dynamics. This diagnostic has three principal features: measurements with time resolution, measurements inside the material and measurements with the depth resolution. Currently, the measurement of the dynamics of the shape of the diffraction peak is demonstrated.

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