ICFRM2007/97
Damage to Preheated Tungsten Targets after Multiple Plasma Impacts Simulating ITER ELMs

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The energy loads onto ITER divertor surfaces associated with the Type I ELMs are expected to be up to 1 MJ/m\textsuperscript{2} during 0.1-0.5 ms, with the number of pulses about 103 per discharge. Tungsten is a candidate material for major part of the surface, but its brittleness can result in substantial macroscopic erosion after the repetitive heat loads. To minimize the brittle destruction, tungsten may be preheated above the ductile-to-brittle transition temperature.

In this work the behavior of preheated tungsten targets under repetitive ELM-like plasma pulses is studied in simulation experiments with the quasi-stationary plasma accelerator QSPA Kh-50. The targets have been exposed up to 450 pulses of the duration 0.25 ms and the heat loads either 0.45 MJ/m\textsuperscript{2} or 0.75 MJ/m\textsuperscript{2}, which is respectively below and above the melting threshold. During the exposures the targets were permanently kept preheated at 650 °C by a heater at target backside.

In the course of exposures the irradiated surfaces were examined after regular numbers of pulses using the SEM and the optical microscopy. The profilometry, XRD, microhardness and weight loss measurements have been performed, as well as comparisons of surface damages after the heat loads both below and above the melting threshold. It is obtained that macrocracks do not develop on the preheated surface. After the impacts with surface melting, a fine mesh of intergranular microcracks has appeared. The width of fine intergranular cracks grows with pulse number, achieving 1-1.5 microns after 100 pulses, and after 210 pulses the crack width increases up to 20 microns, which is comparable with grain sizes. Threshold changes in surface morphology resulting in corrugation structures and pits on the surface as well as importance of surface tension in resulted “micro-brush” structures are discussed. Further evolution of the surface pattern is caused by loss of separated grains on exposed surface with increased number of impacts. Degradation of thermophysical properties of tungsten under multiple plasma exposures is analyzed.