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Simulation of Beryllium Erosion and Surface Damage Under ITER-like Transient Plasma Heat Loads

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The first wall panels of the ITER main chamber will be completely armored with beryllium. The primary reasons for the selection of beryllium as an armor material for the ITER first wall are its low Z, high oxygen gettering characteristics and also high thermal conductivity. During plasma operation in the ITER, beryllium besides low cyclic heat loads (normal events) will be suffered by high transient heat loads, such as ELMs, disruptions, VDE, etc. (off normal events). These transient loads cause rapid heating of beryllium surface and can result in significant changes in surface and near-surface regions, such as material loss, melting, cracking, evaporation and formation of beryllium dust as well as hydrogen isotopes retention both in the armor and in the dust. It is expected that the erosion of beryllium under transient plasma loads such as ELMs and disruptions will have significant impact on lifetime of the ITER first wall.

This paper presents the main results of numerous experiments carried out during some last years at QSPA-Be facility in Bochvar Institute. QSPA-Be facility represents a single-stage coaxial quasi-stationary plasma accelerator with its own magnetic field. It is capable to provide plasma (hydrogen or deuterium) and radiation heat loads on target surface relevant to ITER ELMs and mitigated disruptions. Special Be and Be/CuCrZr mock-ups were tested by hydrogen/deuterium plasma streams (5 cm in diameter) with pulse duration of 0.5 ms in a heat loads range of 0.2-2.2 MJ/m2 and maximum quantities of plasma pulses up to 100-250 shots. The angle between plasma stream direction and mock-ups surface was 30o. During the experiments, the mock-ups temperature has been maintained in the range of RT-500℃. Two beryllium ITER grades: TGP-56FW (RF, Bochvar Institute) and S-65C (USA, Materion Brush) were studied in these experiments. Influences of plasma heat loads, surface temperature and quantities of plasma pulses on the Be erosion and surface damage are presented. The experimental data obtained are used for validation of appropriate numerical models and for the estimation of lifetime of the Be armor.

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