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FEATURES OF SURFACE MODIFICATION OF COPPER-BASED ALLOYS UNDER POWERFUL PLASMA EXPOSURES

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Copper-based alloys are widely used in heat transfer elements for electronics, nuclear fusion technology and many other areas du to their excellent thermal conductivity, strength and fatigue resistance. Such alloys, e.g. Cu-Cr-Zr, could be used as basis to construct heat sinks for first wall and divertor components of ITER. However, various changes of mechanical properties could be driven in copper alloys under the plasma exposures with extreme energy and particle loads.

The report presents experimental results on surface modifications and materials alloying under the plasma exposures. In particular, modification of thin multilayered coatings mixed with Cu substrate in a liquid phase under the plasma processing is analyzed.

Ti-Cr, Ti-Cr-Ti-Nb, Ti-Cr-Ti-Zr, Ti-Cr-Ti-ZrO multilayer PVD coatings have been deposited within a Bulat-type facility. Experiments on surface modification were carried out with a quasi-stationary plasma accelerator QSPA Kh-50. The main parameters of QSPA plasma streams were as follows: ion impact energy was about 0.4-0.6 keV, the maximum plasma pressure amounted to 0.32 MPa, and the stream diameter was equal to about 18 cm. The surface energy loads measured with a calorimeter achieved 0.6 MJ/m^2 and the pulse duration was 0.25 ms. Surface diagnostics included an optical and scanning electron microscopy, profilometry as well as microhardness, roughness and weight loss measurements.

Features of plasma alloying of Cu-based materials with Ti-Cr, Ti-Cr-Ti-Nb, Ti-Cr-Ti-Zr, Ti-Cr-Ti-ZrO have been studied in different regimes of exposures. It is shown that modified surface layer with homogeneous structure and thickness up to 10 μm has been formed in result of pulsed plasma treatment. Influence of plasma impacts on crack development for different copper alloys has been analyzed. Obtained results showed the favorable influence of alloying additions (Cr-Zr, Cr-Nb) on behavior of Cu-based materials under the high heat loads.