ALLOYING AND MODIFICATION OF MATERIALS RELEVANT TO FUSION AND FISSION ENERGY

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The physical processes under high-energy density plasma impacts on the surfaces are rather complex. Broad combination of mechanisms of plasma pulse influence on material properties includes not only the surface damage due to the different erosion mechanisms but also modification of material properties in surface layer due to high-speed quenching, shock wave formation, material alloying with plasma impurities. Thus improvement of physical and mechanical properties of different materials can be achieved also by pulsed plasma alloying and coating modification with pulsed plasma streams.

Modification of thin (1–2 μm) PVD coatings of molybdenum or tungsten coating mixed with substrate in liquid phase under the pulsed plasma (q=0.4 MJ/m^2, puls duration 10-20 μs) processing are analyzed. After alloying of ferritic/martensitic steel EP-823 with Mo the concentration of molybdenum in the modified layer of 15–20 μm achieved 20% for single treatment cycle and 30% after two cycles. The stainless steel (Cr18Ni10Ti) surfaces coated of tungsten have been alloyed and modified with hydrogen powerful (q=0.6 MJ/m^2, pulse duration of 250 μs) plasma streams. The plasma exposures result in modification of steel-based materials and formation of re-solidified layers. The concentration of tungsten is amounted to 2 atomic percent in modified subsurface layer.

Decrease of grain sizes (from tens of μm to hundreds of nm), roughness and porosity were obtained by plasma irradiation of thick (~0.1–0.3 mm) plasma sprayed coatings of Co-32Ni-21Cr-8Al-0.5Y and Ti64. A modified layer with homogeneous structure and thickness up to 50 μm is formed as a result of plasma treatment.

Changes of physical and mechanical properties of hafnium, zirconium based alloys and Hastelloy under the influence of pulsed plasma streams treatment is also studied. The modified layer resistant to etching with homogeneous structure and thickness up to 20 μm is formed as a result of plasma treatment. Plasma processing resulted in development of nano- and submicron cellular structures in surface layer of Hastelloy N samples. Ordered cellular structures form specific morphology with average cell size of about 200 nm. Decreasing grain size and amorphous transformations are found to be important for improvement of corrosion properties of this material.

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