

MULTILAYER TUNGSTEN/QUASI-CRYSTAL Ti-Zr-Ni SYSTEMS AS PROMISING MATERIALS FOR PROTECTIVE ELEMENTS IN A FUSION REACTOR

Malykhin S.V., Kopylets I.A., Surovitskiy S.V., D.V. Konotopsky. L.E. Lytvinyuk
National Technical University “Kharkiv Polytechnic Institute”, Kharkiv, Ukraine,
serhii.malykhin@kphi.edu.ua

The formation of durable systems and materials operating under the conditions of particle, plasma, and thermal loads in nuclear and thermonuclear reactors is a problem that can be addressed by acquiring new knowledge about induced physicochemical processes. Understanding the impact of plasma on components directly exposed to the plasma or in direct contact with the reactor casing, such as the divertor and the first wall, is of significant importance. Tungsten is currently considered the best energy absorber for hydrogen plasma disruptions in the reactor due to its low sputtering rate, high melting threshold, and high thermal conductivity. However, the gradual accumulation of internal macrostresses and the development of surface cracks contribute to considerable macroscopic erosion of tungsten, and the accumulation of hydrogen, D⁺, T⁺, He⁺, leads to embrittlement. To address this issue, the use of multilayer systems W/Ti-Zr-Ni quasicrystals (QC) or QC/W compositions is proposed. Practical research on the radiation resistance of such materials for use in nuclear and thermonuclear energy is necessary. The study presents results on the thermal stability of a laboratory model multilayer periodic coating consisting of alternately deposited layers of Ti₄₁Zr₄₁Ni₁₈ with a thickness of 10.5 nm and W layers with a thickness of 2.5 nm.

It was found that annealing in the temperature range from 500°C to 700°C in Ti₄₁Zr₄₁Ni₁₈/W multilayer periodic coatings caused changes only in the Ti₄₁Zr₄₁Ni₁₈ layers, while the tungsten layers underwent no significant changes. The phase transformation from quasicrystal to crystalline approximant 2/1, occurring at 700°C, was accompanied by an 8.3% increase in volume compared to the volume of the quasicrystalline phase. The multilayer construction proved to be stable up to 700°C and, despite the phase changes, did not lose adhesion to the substrate. The combination of materials and annealing temperatures did not generate significant internal stresses and did not lead to mechanical damage. The experimental data obtained in the study allow for the controlled formation of multilayer nanocomposites and layered microsystems of various constructions, combining layers of different thicknesses. Further, it is advisable to conduct real tests of Ti₄₁Zr₄₁Ni₁₈/W coatings of different constructions under irradiation with high-power hydrogen plasma to study radiation-thermal stimulated processes.