STRUCTURAL-PHASE CHANGES IN THIN FILMS AND SURFACE LAYERS OF Ti41.5Zr41.5Ni17 ALLOY, STIMULATED BY RADIATION-THERMAL IMPACT OF HYDROGEN PLASMA

malykhin@kpi.kharkov.ua

Surovitskiy S.V.[1], Herashchenko S.S.[2], Makhlaj V.A.[1,2], Malykhin S.V.[1], Kopylets I.A.[1]

[1]National Technical University "Kharkiv Polytechnical Institute", Kharkiv, Ukraine;
[2]Institute of Plasma Physics NSC "Kharkov Institute of Physics and Technology", Kharkiv, Ukraine.

The behavior of the bulk and film samples of the Ti40Zr43Ni17 alloy (wt%) was investigated. Interest in this system is due to the fact that it is possible to form a stable (up to ≈660 C) quasicrystalline icosahedral phase with a set of unique physical properties, which makes it promising for use in plasma installations. To date, quasicrystalline film coatings have been not prepared by anyone. Bulk samples were obtained by vacuum fusion of ultrapure components under ultrapure conditions. Film samples (h = 14.8 μm) were prepared by direct-current magnetron sputtering of a target in an argon medium at a pressure of 2×10^{-3} mm Hg. The target-substrate distance was 30 mm. Substrates were Si, glass and steel Eurofer.

Heat flux tests of the samples were performed with hydrogen plasma streams produced by the quasi-steady-state plasma accelerator QSPA Kh-50 (NSC KIPT). The main parameters of QSPA plasma streams were as follows: ion impact energy about 0.4 keV, the maximum plasma pressure 3.2 bars, and the stream diameter about 18 cm. The surface energy loads measured with a calorimeter achieved 0.6 MJ/m2 (near the tungsten melting threshold). The plasma pulse shape was approximately triangular, and the pulse duration was 0.25 ms. A surface analysis was carried out Scanning Electron Microscopy (SEM) of the JEOL JSM-6390 type. To study a micro-structural evolution of the exposed targets, the X-ray diffraction technique (XRD) has been used. Quasi-crystalline phase identification was carried out in conformity with the Cahn´s methodology using indices N and M. To simulate the diffraction pattern, the software package Powder Cell 2.1 was used.

The initial state of the bulk samples (targets) is characterized by the presence of two crystalline phases: phase of an approximant crystal 1/1 (W phase) with a period a_W = 1.42 nm and a Laves phase (Ti, Zr) Ni of structural type C14. The initial state of the film samples was nanocrystalline with crystallite size about 2 nm.

Irradiation of a bulk sample with plasma led to the disappearance of the Laves phase, a decrease in the amount of the W phase with a_W = 1.426 nm, and the formation of the supposed crystal phase of the 2/1 approximant. After irradiation of the film sample, formation of a quasicrystalline phase with a quasicrystallinity parameter a_q = 0.5135 nm and crystallite size about100 nm as the main phase was revealed; as well, W-phase in an amount of 20-30% with a period a_W = 1.41 nm was found, which practically corresponds to the theoretical crystallographic relationship between icosahedral and crystalline related structures a_W^{teor} = 1.413 nm. According to SEM data, after the action of plasma, characteristic rectilinear cracks are found on the surface of the film sample.