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RESIDUAL STRESS IN THE TINI SMART-MATERIAL AFTER ADDITIVE THIN-FILM ELECTRON-BEAM SYNTHESIS OF TI-NI-TA-SI SURFACE ALLOY*

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It is known that NiTi SMART-materials have shape memory effect and super-elasticity features. These materials are widely used in biomedicine (surgical stents, catheters) [1, 2] and industry (aerospace drives, sensors, seals) [3, 4]. The key issue responsible for degradation of functional properties of TiNi during operation is residual stresses arising from the sample processing and surface treatments. Recently, a novel method of surface modification of TiNi alloys has been proposed using an additive thin-film electron-beam synthesis of surface alloy [5].

The purpose of this work is X-ray diffraction examination of residual stresses formed in the near-surface layer of TiNi substrate after additive thin-film electron-beam synthesis of Ti-Ni-Ta-Si surface alloys.

The initial specimens at room temperature possess a three-phase mixture: a B2 phase (∼85 vol.%), a Ti_2Ni phase (∼10 vol.%) and a Ti_3Ni_4 phase (∼5 vol.%). The magnetron co-deposition was performed through simultaneous sputtering of three targets {Ti, Ta, Si} on the surface of TiNi substrate to obey the composition $Ti_{60}Ta_{30}Si_{10}$ (at. %). For magnetron sputtering, we used cathodes made of pure elements Ti (99.95 wt. %), Ta (99.95 wt. %), and Si (99.95 wt. %) (Girmet, Russia). The deposition time was chosen in order to deposit a ~100 nm thick film on the surface of TiNi substrate. An additional post electron-beam treatment was employed with an energy density E_s = 1.7 J/cm^2 and pulse number n = 10. Formation of surface alloy on TiNi substrates and additional post electron-beam treatment was carried out in a single vacuum cycle on the modified setup "RITM-SP" (Microsplav Ltd., Russia) [6].

In this work, the fabricated Ti-Ni-Ta-Si surface alloys possess a multi-layered structure consisting of outer glassy layer and adjacent sublayers of TiNi substrate: eutectic B2+Ti_3Ni_4, martensitic R/B19' and heat-affected zone. The detailed XRD, TEM/EDS analysis revealed formation of two isostructural B2 phases with different lattice parameters, chemical compositions and microstructure. Changes of B2 lattice parameters are closely related with variation of chemical composition and residual elastic stresses of the first kind. The XRD determination of residual stresses in the as-cast samples has shown that compression stresses in the direction perpendicular to the irradiated surface reach a value of –350 MPa. Post electron-beam treatment results in decreasing of compression stress value down to –270 MPa. Based on the microstructural characterization, the step-by-step scenario of formation and evolution of residual stress fields after the synthesis of surface alloy and post electron-beam treatment of TiNi substrates is given.

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