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Ludmila Meisner, J Nanomed Nanotechnol 2018, Volume 9
DOI: 10.4172/2157-7439-C10-093

JOINT EVENT

28th International Conference and Expo on
Nanoscience and Nanotechnology

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3rd World Congress and Expo on
Graphene & 2D Materials

November 26-28, 2018 | Barcelona Spain

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Multicomponent Ti-Ta/Nb-Ni based surface alloys with an amorphous-nanocomposite structure on TiNi substrates: thermodynamic modeling, thin-film electron-beam synthesis, atomic structure, physical and mechanical properties

TiNi shape memory alloys (SMAs) have found many advanced applications in medical and engineering devices due to combination of superelastisity and high corrosion resistance. Two of the critical issues limiting the application of TiNi SMAs are a danger of toxic Ni release into the adjacent tissues and insufficient level of X-ray visibility. These limitations can be overcome by fabrication of a Ti-Me (Me:Ta, Nb) based surface alloys on the TiNi substrate. These alloys have good mechanical compatibility with TiNi substrate. This approach is realized through the multiple alternation of magnetron co-deposition of Ti-Ta or Ti-Nb thin (50–100 nm) films and their liquid-phase mixing with the TiNi substrate by microsecond low-energy, high current electron beam (≤ 15 keV, ~2 J/cm2). Compositions of surface alloys are predicted based on the thermodynamic analysis of ternary Ti-Ta/Nb-Ni systems. As a result of pulsed electron-beam melting of film/substrate systems, a certain type of structure should be formed: amorphous-nanocrystalline (nanocomposite) or completely amorphous. Surface SEM/EDS, AES, XRD/GIXRD and cross-sectional HRTEM/EDS/SAED techniques were used for microstructural characterization of the studied surface alloys. The amorphous and nanocrystalline structure of the surface Ti-Ta-Ni alloy is described in detail. It has a multilayer structure associated with additive fabrication processes and consists of the subsurface amorphous sublayer and several underlying nanocrystalline sublayers with fine (10–15 nm) and "coarse" (80–100 nm) alternating with each other. It was revealed by nanoindentation possesses a predicted mechanical compatibility to TiNi substrate.

Biography

Ludmila Meisner has completed her PhD from Tomsk State University and postdoctoral studies from the Institute of Strength Physics and Materials Science (ISPMS) SB RAS, Tomsk, Russia. She is the Principal Investigator of the Laboratory of Shape Memory Alloys of ISPMS SB RAS and Professor of Tomsk State University. She has published more than 170 papers in reputed journals. Her professional interest are in titanium nickel, Ti-based alloys, surface, coatings, nanostructure, surface modification, electron beam impacts, ion-plasma surface nanoengineering, X-ray diffractometry, electron back-scatter diffraction, scanning and transmission electron microscopy.

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