

ABSTRACT

Dissertation work: 104 p., 36 fig., 9 table, 70 literature sources.

"OXYGEN PUMP", MASS TRANSFER, NANOSCALE FILMS, SURFACE, RARE EARTH ELEMENTS, PHASE FORMATION.

Subject of the study: processes of structural and phase transformations in the bulk and in near-surface layers in Pd(30 nm)/Ho(20 nm)/SiO₂ V(25 nm)/Ag(25 nm)/SiO₂ nanoscale systems.

Objective of the study: establishment of the phase formation and mass transfer regularities in nanoscale film systems (V/Ag, Pd/Ho) based on metals with different affinity to oxygen at heat treatment in different ambients.

Methods of the study: electronography, grazing-incidence x-ray analysis (GIXRD), secondary neutral mass spectrometry (SNMS), transmission electron microscopy and atomic force microscopy (AFM).

Scientific novelty:

1. Nanoscale factor influence was shown: the formation of phases occurs in other sequences than in bulk materials. In the system V(25 nm)/Ag(25 nm)/SiO₂: $V \rightarrow V_xO_y(\text{FCT}) \rightarrow V_xO_y(\text{FCT})+V_xO_y(\text{monoclinic}) \rightarrow V_xO_y(\text{FCT}) \rightarrow VO \rightarrow V_2O_3$. In the system Pd(30 nm)/Ho(20 nm)/SiO₂ after annealing in vacuum and in hydrogen ambient at temperature of 350 °C forms the Pd₃Ho phase.

2. The influence of physical-chemical state of the outer surface on the phase formation processes in the bulk of thin film compositions is shown. Annealing in vacuum and in hydrogen stimulates the diffusion of the lower-layer material – Ho by grain boundaries of Pd to the surface, and the processes of oxide and hydride formation on the outer surface acts as an additional driving force for mass transfer; heat treatment of the V/Ag system in oxygen atmosphere stimulates the diffusion of silver atoms by vanadium grain boundaries to outer surface that reduces the surface energy of the system and becomes an additional driving force for mass transfer in this case.

3. It is shown that annealing in hydrogen compared to annealing in vacuum impedes the Pd₃Ho intermetallic phase formation. Oxide and hydride formation on the outer surface affects on the regularities of phase formation in the interface Pd/Ho.

4. It is found that in the V/Ag system thermally induced diffusion of silver by grain boundaries slows down the process of vanadium lattice distortions as a result of oxidation and prevents the crystal structure defectiveness increase the during annealing.

Work was carried out under the state budget theme № 2811 «Construction of gradient states in nanolayer metal film compositions through the processes on the outer surface» commissioned by the Ministry of Education and Science of Ukraine.

Scientific results obtained in this work have a practical interest to develop regimes of thermal treatment in obtaining pre-defined surface and bulk structure-phase states in thin-film technology and micro-instrument engineering.