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Research Article

EMISSION AND ADSORPTION PARAMETERS OF RARE EARTH METAL FILMS ON THE SURFACE OF MOLYBDENUM - RHENIUM ALLOY SINGLE CRYSTAL

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Tulametov Makhmudjan Akhmedovich
Senior Lecturer, Department of Physics and Electrical Engineering, Tashkent Institute of Chemical Technology, Tashkent, Uzbekistan

Bozorov Ismoil Tukhtaevich
Senior Lecturer, Department of Physics and Electrical Engineering, Tashkent Institute of Chemical Technology, Tashkent, Uzbekistan

ABSTRACT

Study of the adsorption nature, emission - adsorption parameters of La, Sm, Gd films on the surface of the sharp monocrystal of the molybdenum alloy - rhenium CCC and GPU structure and the establishment of general laws and regulations of the adsorption nature of these rare earth metals.

KEYWORDS

Adsorption; rare earth metals; emission paramets; exit operation; desorption heat; acute single crystal.

INTRODUCTION

Interest in the study of films of rare earth metals on the surface of refractory metals is associated with the search for new highly efficient film substrates for thermionic emitters. Studies of the films of these metals on the surface of the faces of metallic single crystals made it possible to establish a relationship between the variable valence of some rare earth metals on the surface

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of their own and foreign substrates with the structure of the surface film. Features of the electronic structure of rare earth metals - the filling of the inner 4f - shell with an increase in the atomic number of elements in the series of lanthanides - are responsible for their interaction one after another and the atoms of the substrate. Establishing the nature of this connection can be facilitated by the study of the novelty of atoms of rare earth metals on various adsorbents. To date, sufficiently detailed studies of the surface of rare earth metal atoms on the surface of single crystals of the BCC (body-centered cubic) structure have been carried out and the general nature of adsorption on these crystals has been established, regardless of the individual properties of each of the rare earth metal elements [1-4].

The conclusion of the determining role of this commonality is the nature of the electronic structure of rare earth metals is given and verified by experiments on the adsorption of various representatives of rare earth metals on the surface of single crystals of the HCP(hexagonal close-packed) structure. The use of field electron microscopy makes it possible, in relatively simple experiments, to study the crystal structure of a single crystal - an adsorbent of the adsorption density of foreign atoms over its surface. In this case, it is possible to study the nature of the rearrangement of the crystal surface under the influence of temperature and electric field, i.e. the conditions for studying the adsorption of foreign atoms under identical vacuum conditions on modified single-crystal surfaces are provided. The research carried out represents an important role for the physics of surface phenomena, since the mechanism of adsorption bonds of a group of chemical elements – lantonoids is studied.

The thermionic parameters of the polycrystalline wire of molybdenum-rhenium alloy were measured in the work. The method of field electron microscopy established the transition of a single crystal of the molybdenum-rhenium alloy from the BCC to the HCP structure. The dependence of the work function of the surface of a molybdenum - rhenium single crystal on the degree of coating with La, Sm, Gd films was studied. The heat of desorption of various rare-earth metals from the surface of a molybdenum-rhenium single crystal has been measured.

Studying the temperature regime of crystal rearrangement, it was experimentally established that after heating in a vacuum above 2000 K, a pointed single crystal is rearranged in a BCC lattice - in HCP. Thanks to this, it was possible to conduct a study of films of rare earth metals on one material in two crystalline modifications.

The distribution of the adsorbate with optimal coverage on the surface of the BCC crystal for all rare-earth metals studied is the same as for pure refractory BCC metals W, Mo. The regions (111) and (112) make the main contribution to the emission. Films of atoms of rare earth metals at the optimal degree of coverage of a single crystal of BCC structure are predominantly adsorbed on loose faces, saturating dangling bonds.

The dependence of the work function on the degree of coverage has a normal yield with a minimum at optimal coverage, conditionally taken as $\theta = 1$. It should be borne in mind that

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although in these experiments the total current from the surface of a single crystal was measured, the actual obtained values of the minimum work function characterize the faces (111) and (116), which under these conditions make the main contribution to the total current. For the same reason, the values of the heat of desorption of rare-earth metal (REM) atoms from the surface of a molybdenum-rhenium crystal characterize the binding energy with the same loose faces. Table 1 shows the average values of the work function at optimal coverage (eφmin), in a thick layer (eφt.s) and the value of the heat of desorption (qdec) in the range of coverage degrees 0.8<θ<1.

An emission-microscopic study of the adsorption of La, Sm, Gd on the surface of a pointed HCP, a molybdenum-rhenium alloy crystal, showed that the anisotropy of an equilibrium submonolayer coating is qualitatively general for all rare-earth metals studied and does not depend on the orientation of the axis of a pointed single crystal. At low degrees of coverage of adatoms of rare earth metals (θ<0.5), the contrast of the emission image increases compared to a clean surface due to the preferential activation of faces with low work function. With the optimal degree of coverage, the main emitting faces in all cases studied are the (1120) and (1010) type faces. Since under these conditions, the overwhelming part of the emission current comes from these faces, the results of measurements of the work function and the heat of evaporation characterize these faces.

Table 1

Emission-adsorption parameters of REM adatoms on the surface of a BCC crystal of molybdenum-rhenium alloy (in EV)

	Molybdenum-rhenium			Tungsten	
REM	$e\varphi_{min}$	$e\varphi_{т.с}$	$q_{дес}$	$q_{субл}$	$q_{дес}$
La	2,5	2,7	5,8	4.47	5,8
Sm	2,4	2,5	5,2	2,13	3,8
Gd	2,9	3,1	5,3	4,15	5.1

Measurements in the device with a oscillating tip were performed during adsorption and desorption of Gd and Sm from the (111), (100) type faces of a molybdenum–rhenium alloy single crystal and after rearranging the tip of the same tip into an HCP structure. Table 2 shows the measurements of the work function on the faces at optimal (eφmin) coating in a thick layer (eφt.s), as well as the heat of desorption in the region of change in the degree of coverage from optimal to 0.8 optimal.

Table 2

Emission-adsorption parameters of Gd and Sm films on the faces of BCC and HCP crystals of molybdenum-rhenium alloy

REM	BCC			HCP		
	edge	$e\varphi_{min}$	$q_{дес}$	Грань	$e\varphi_{min}$	$q_{дес}$
Gd	(111)	3,1	5,1	(1231)	3,3	5,1
	(100)	2,1	5,0	(1120)	2,6	5,1
Sm	(111)	2,87	4,5	(1231)	2,9	4,8
	(100)	2,2	4,9	(1120)	2,5	4,9

The greatest decrease in the work function during the adsorption of rare earth metals on a BCC crystal of an alloy of molybdenum - rhenium is observed on loose faces (111), (116) on the same faces, the heat of desorption of atoms of rare earth metals is the highest. The same trend takes place during the adsorption of rare earth metals on the faces of HCP crystals of the molybdenum-rhenium alloy.

The results of measuring the parameters from the surface of the (111) faces of the BCC crystal and (1120) HCP crystal, given in Table 2, are in good agreement with the results of measuring the parameters of the Sm – Gd films from the surface of the entire crystal, because the emission of electrons from these faces makes the main contribution to the total emission with optimal coverage.

The results of the experiments performed indicate that the anisotropy of adsorption of various representatives of the group of rare earth metals on the surface of an HCP crystal is determined by the common structure of the electron shells of these elements and does not depend either on the chemical nature of the adsorbate or on the individual physical properties of the element of rare earth metals.

CONCLUSION

In conclusion, we can draw the following conclusions:

Pointed monocrystals from an alloy of molybdenum - rhenium can be in BCC and HCP structures;

Adsorption of rare-earth metals on the surface of a BCC molybdenum-rhenium alloy crystal with optimal coverage, adsorption occurs on faces of the (111) and (112) types, as well as on pure BCC metals;

Predominantly, adsorption occurs on the faces of the HCP crystal with a relatively high value of the specific surface energy.

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