Next Experimental Confirmation of Validity of the Phenomenon of Phase Formation through a Stage of Liquid State in Metals being Electrodeposited

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In the works [1,2] the experimental proofs of validity of the phenomenon of phase formation through a stage of liquid state in metals being electrodeposited were presented. The aim of this work was further confirmation of validity of the discovered phenomenon. General idea of the performed investigations was as follows. As metals being electrodeposited crystallize in atmosphere of evolving hydrogen, they should possess structural features typical for metals solidified from liquid state in saturated hydrogen environment.

First idea and its realization. It is known that melted polymorphous metals solidify in saturated hydrogen environment forming the crystal structure with the type of intermediate modification. If polymorphous metals being electrodeposited really pass through a stage of liquid state, they will crystallize forming the structure with the type of intermediate modification.

As the result of the completed investigations it was found, that saturation of cobalt being electrodeposited by hydrogen causes its crystallization with the formation of the f.c.c. structure of β-Co intermediate modification. Crystallization of cobalt melt in saturated hydrogen environment was performed at specially developed unit allowing obtaining of metals saturated by hydrogen at high temperatures (up to 1800 °C) and pressures (up to 10.0 MPa). X-ray structure analysis of ingots indicates that cobalt crystallized in hydrogen environment possesses the f.c.c. structure of β-Co intermediate modification.

Second idea and its realization. It is known that as a result of crystallization of cast melt in saturated hydrogen environment the pores are being formed in the ingot being solidified because of the emission of hydrogen dissolved in metallic liquid phase. Therefore, in case of validity of the discussed phenomenon porous structure of electrodeposited metal should have typical features of porous structure of cast metal solidified from liquid state in saturated hydrogen environment.

The microstructure of electrodeposited chromium was compared with the one of cast metals melted and solidified in saturated hydrogen environment at specially developed unit at the adjustable rates of movement of plane crystallization front being 1.0 and 1.3 mm/sec. Comparative analysis shows that porous structure of electrodeposited metal possesses all typical features of porous structure of cast metal solidified from liquid state in saturated hydrogen environment (Fig. 1).

Third idea and its realization. It is known that pores volume in metal solidified in saturated hydrogen environment is proportional to the quantity of hydrogen dissolved in the melt. Therefore, in case of validity of the discussed phenomenon the porosity of electrodeposited metal should depend on the degree of its saturation by hydrogen during electrodeposition.

On the basis of the analysis of the investigations results it was found that saturation of copper being electrodeposited by hydrogen is one of the main factors determining its porosity. At that, the growth of the degree of saturation of metal by hydrogen during its electrodeposition causes the increase of both the relative area of pores and their quantity (Fig. 2).

Thus, the discovered phenomenon of phase formation through a stage of liquid state in metals being electrodeposited is confirmed by:

- crystallization of polymorphous metal being electrodeposited as the intermediate modification identical to the one of polymorphous metal solidified from liquid state in saturated hydrogen environment, and the fraction of which increases with saturation of deposits being formed by hydrogen;
- formation of porous structure in metal being electrodeposited, which possesses all typical features of porous structure of metal solidified from liquid state in saturated hydrogen environment, that consist of the similarity of orientation and form of pores as well as the presence of the effects of pores coagulation, discontinuance of pores growth and initiation of new pores during the whole period of crystallization during electrodeposition;
- growth of metal porosity with the increase of its saturation by hydrogen during electrodeposition.

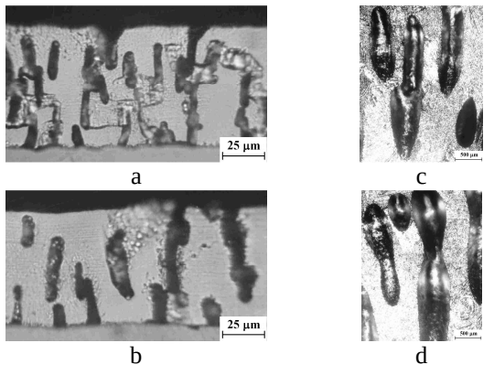

Fig. 1. Cross-section microstructures of chromium samples electrodeposited in the universal electrolyte at the temperature 45 (a) and 50ºC (c) and one of aluminum bronze samples melted and solidified in hydrogen environment at the rate of movement of the plane crystallization front 1.0 mm/sec (c,d)

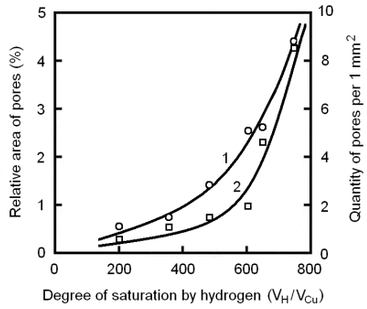

Fig. 2. Influence of saturation degree of copper by hydrogen during its electrodeposition on relative area of pores (curve 1) and their quantity per 1 mm^2 (curve 2)

References

1. O.B. Girin. Phase and Structure Formation of Metallic Materials Electrodeposited via a Liquid State Stage: New Experimental Proof // *Defect and Diffusion Forum*, 2010, V. 303-304, P. 99-105.
2. O.B. Girin. Phase Formation through a Stage of Liquid State in Metallic Materials being Electrodeposited: Recent Experimental Proofs // *International Journal of Material Science*, 2012, V. 2, № 4, P. 108-118.