

New Conceptions on the Structure Formation of the Metals Being Electrodeposited, and their Usage for the Development of Corrosion-Proofing Technologies for Canned Food Steel Sheet

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During the recent years a lot of experimental data has been accumulated that could not be explained on the basis of the available knowledge on the structure formation of the metals being electrochemically deposited. An analysis of this data permitted to suggest that metals in the process of their electrochemical deposition pass through a stage of their liquid state. To verify this suggestion there has been invented a method of X-ray structure analysis that was used to study the phase transformations and the structural changes of metals directly during their electrochemical deposition. There has been experimentally disclosed an earlier unknown phenomenon of structure formation in the metals being electrochemically deposited through a supercooled metal liquid. The feature of this phenomenon is that during the electrochemical deposition of the metal in an aqueous medium onto a solid cathode a supercooled metal liquid is formed and solidified at the deposition temperature in the form of a crystalline and/or amorphous phase [1,2].

Theoretical studies proved that a liquid state of the metal being electrodeposited is formed as a result of a chain reaction of the electrochemical formation of atoms. While the metal is electrodeposited on the cathode as a result of the chain reaction there occurs an avalanche-like formation of atoms that have no long-range order in their arrangement. Hence, the revealed phenomenon is explained by a very fast (explosion-like) character of metal precipitation as a result of the chain reaction of the electrochemical formation of atoms and of the transition of the atom clusters from their liquid state to a more stable solid state [2].

To study the revealed phenomenon there have been developed new and have been upgraded the available methods of X-ray structure analysis that allow to obtain reliable data on the texture, substructure, structure inhomogeneity and structural state of the electrodeposited metals [3]. The set includes twelve X-ray structure methods, while the novelty of the four of them is protected by Inventor's Certificates. The results of the multiple and diversified experiments proved that the found phenomenon is demonstrated by the inherent modifications of the microstructure, substructure, structural state, crystallographic texture, surface morphology, structural inhomogeneity and defects in the crystalline lattice of metals with an increase in the supercooling degree during their electrodeposition [4].

The validity of this phenomenon was proved experimentally by the facts of the existence in the electrodeposited metals of metastable structures corresponding to: i) the amorphous structure of the solidified metal liquid (Fig. 1), ii) the highly defective crystalline structure of the metal quenched from its liquid state, and iii) the intermediate modifications that had appeared during the superfast crystallization of the liquid phase of the polymorphous metal (Fig. 2). The validity of this phenomenon was experimentally confirmed by the

facts: i) of the formation of metallic compounds at the electrodeposited metal/metallic cathode interface, and ii) of the formation of primary solid solutions and intermediate phases during the alloying of the metals being electrodeposited.

The described phenomenon was used in the development of the technologies of canned food steel sheet corrosion-proofing intended to upgrade its quality, to reduce its production cost and to make its production less environmentally hazardous. On the basis of the new conceptions on the formation of the structure of the metals being electrodeposited there has been developed a technology of producing on a canned food steel sheet of i) a protective nanostructural composite 0.01-0.03 μm thick chromium coat from a low-concentration electrolyte based on hexavalent chromium compounds; ii) a protective amorphous composite 0.01-0.03 μm thick chromium coat from a low-toxicity electrolyte based on trivalent chromium compounds, and iii) a protective textural composite 0.1-0.3 μm thick tin coat from a low-toxicity electrolyte.

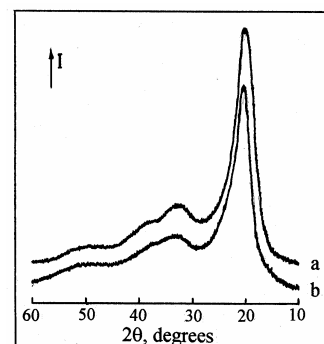


Fig. 1. Diffractograms of chromium (a) and nickel (b) alloyed during the electrodeposition by carbon and phosphorus respectively showing an amorphous structure of the solidified supercooled metal liquid, Mo-K α .

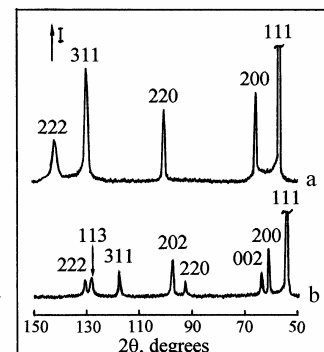


Fig. 2. Diffractograms of the electrodeposited cobalt (a) and manganese (b) displaying intermediate modifications β -Co and γ -Mn arising during the superfast crystallization of the liquid phase of the polymorphous metal, Fe-K α .

References

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