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Abstract

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On the Mechanism of Electrolytic Polishing of Metals and the Structure of an Electropolished Surface

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Recently, the view has been persistently advanced that the process of electrolytic polishing of metals proceeds in two stages, with different mechanisms ([1]). In the first, preparatory stage, at relatively small polarizations, structural etching of the surface of the specimen takes place, along with preferential dissolution of its most protruding areas, with the formation of clearly expressed dissolution figures. In the second, decisive stage, at large polarizations, the process of suppressing structural etching begins, and a smooth surface, devoid of any traces of structure, is gradually formed.

In explaining the mechanism of the first stage, it is assumed that the crystallographic orientation of the metal grains has a decisive influence on the dissolution process; while to explain the mechanism of the second stage, various other causes are invoked, naturally no longer connected with crystallographic orientation. It is believed that the concepts set forth have direct experimental confirmation in the study of the structure and properties of the electropolished surface.

Thus, the question of the mechanism of electrolytic polishing is directly connected with the question of the structure of the electropolished surface. The presence of structure should indicate one mechanism, and its absence—another.

The electron-microscopic study of the electropolished surface carried out by us ([2]) shows that the concept of two different stages of electrolytic polishing with two different mechanisms, and especially the concept of the suppression of structural etching in the second stage, is far from indisputable.

In the present communication, some results of these investigations are published.

Experimental Part

Electropolished specimens of polycrystalline copper (M-1) were studied. Electropolishing was carried out in a 5-M solution of phosphoric acid at a terminal voltage of 1.2 V, a current density of 12.5 A/dm^2, and a bath temperature of 20°.

Colloidal replicas were taken from specimens subjected to electropolishing for various time intervals (10, 25, and 180 sec.); after chromium shadowing, these replicas were studied in an electron microscope at a magnification of 1150×. The photographs given below were made in combination with optical magnification (up to 23000×).

As the microphotographs in Figs. 1 and 2 show, in the first stage of the electropolishing process (100 sec.) active structural etching occurs, the scale of which varies depending on the degree of electrochemical inhomogeneity of the surface. In some areas (Fig. 1) structural

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Fig. 1

Fig. 2

Fig. 3

Fig. 4

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Fig. 1a. —Microradiogram of a chalcopyrite particle of the foam product of flotation with ethyl xanthate. 350×; b —microradiogram of the corresponding reference specimen.

etching reveals large and deep etching figures, indicating a relatively greater electrochemical heterogeneity. In others (Fig. 2) these figures are considerably smaller and less deep, in accordance with a smaller difference in electrochemical heterogeneity. In both micrographs, much finer etching figures are also clearly visible, covering the surface of the large figures. They are evidently due to the presence of dislocations and distortions in the bodies of the crystals.

Consequently, already at this initial stage of electropolishing a substantial difference is found in the scales of etching, corresponding to the difference in the degree of electrochemical heterogeneity of the initial surface.

Increasing the duration of electropolishing to 25 sec. (Fig. 3) leads to a further change in the scales of structural etching. Of the large etching figures, only traces remain in the form of relatively dark spots, while the small etching figures undergo some development.

A further increase in the duration of electropolishing to 180 sec., i.e., transition to the stage which is usually regarded as the decisive stage of the process, does not introduce any substantial qualitative changes into the picture of structural etching. The very finest etching figures that arose in the first stage undergo only further development, now constituting the distinct structure of the electropolished surface (Fig. 4).

The micrographs presented do not indicate any suppression of structural etching over the entire course of the electropolishing process. There is only a regular

change in the scales of etching, governed by the change in the scales of electrochemical heterogeneity of the surface. Indeed, if suppression of structural etching were taking place, it would first of all be reflected in the removal of the finest etching figures, as the most readily susceptible to suppression. The micrographs, however, indicate, on the contrary, the gradual development of these very finest etching figures.

The results presented are another visual illustration of the concepts we are developing concerning the structure of the electropolished surface ([3]) and coincide in their substance with the data of other investigators ([4]).

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CITED LITERATURE

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Note: Figure translations are in progress. See original paper for figures.