DETECTION OF THE STRUCTURE OF SINTERED MATERIALS OF THE Me - MeO SYSTEM BY IONIC BOMBARDMENT*

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A study of the structure of sintered aluminum powder material (SAP) by the ionic bombardment method showed the practical value of this method for the investigation of materials produced by means of powder metallurgy.

The method may be used for the preparation of specimens for examination in the electron microscope. A study of photomicrographs shows that the base of SAP is a cellular network consisting of oxide particles forming the boundaries of aluminum pseudograins.

The production in the USSR of new forms of machines and equipment, subjected during operation to considerable thermal stresses, and also that of light-weight constructions, have led to the necessity for developing new materials.

The application of powder metallurgy methods in the production of these materials has currently increased considerably. In particular, such a common material as aluminum, processed by the methods of powder metallurgy, has acquired a number of interesting properties, above all high-temperature strength. Whereas an ordinary aluminum alloy can be used at the most up to 250°C, SAP, i.e., material made of sintered aluminum powder, can be used for protracted loads at 500-600°C, and for short-time loads at 1000°C or above.

Such a possibility is ensured by the presence in the structure of SAP of an oxide component, which is the principal strengthening phase. Until recently, several points of view have existed with regard to the nature of the high strength of SAP. A number of investigators consider that the strength of SAP is due to the small dimensions of the particles of oxide phase (Zeerleder, Irman, Romer). Mott and Orowan consider that the strength of SAP is a function of the distance between the particles. A. I. Paisov, et. al., however, throw doubt on this supposition in view of the uneven distribution of the particles in the matrix. Lenel, et. al. explain the high mechanical properties of SAP at low plasticity by the interaction between the finely disperse phase and dislocations [1]. Paganelli considers that the structure of SAP represents a block base of disperse oxide particles, the oxide phase being arranged along the aluminum subgrain boundaries with still smaller oxide particles imbedded in them. At the same time, the particles are crushed during the deformation process [2]. Consequently, this assessment of the structure agrees with our previously expressed views [3].

The lack of unity in the views on this question may be explained primarily by the fact that the old methods of structural analysis fail to provide clearly visible evidence of the ordered distribution of the strengthening phase in SAP.

By analysing the structure of SAP as revealed by chemical etching or even electroetching, it is difficult to detect in the background of aluminum matrix (Fig. 1) anything but a uniform alternation of finely disperse oxide particles (or etch pits). Photographs of the structure obtained in the electron microscope under high magnification also fail to provide a definite answer regarding the character of the distribution of the two phases (Fig. 2). Recently, ionic etching has become widely used in addition to chemical etching.

In cathode sputtering occurring during ionic bombardment, the material disintegrates along the grains of the polycrystal, at places where the crystal lattice is disturbed, in areas where impurities have accumulated, i.e., where

the atomic bonds are weakened, depressions of varying magnitude being produced at these places. Furthermore, due to the different coefficients of expansion of the different metals, it is found possible to reveal individual structure constituents.

In the experiments described, ionic etching was carried out using apparatus UNT-3, developed by the Electronic Optics Laboratory of the Physics Faculty of the Moscow State University. This apparatus makes it possible to carry out 1) heating of the sputtered specimen to 1200°C, 2) cooling of the specimen during etching, 3) observation of the microstructure of the specimen in the sputtering process, 4) tension or compression of the specimen, 5) application of a film immediately after sputtering for the subsequent examination in the electron microscope, 6) etching of the specimen under forced conditions.

The vacuum system of the apparatus is adapted for operation in a current of inert gas. Evacuation is effected through a vacuum conduit connecting the camera to the vacuum distribution system. To the latter is connected an IVL-100 diffusion pump and a VN-461 backing pump.

In the upper exposure part of the camera is an inspection window, through which the sputtering process may be observed visually. For optical examination of the sputtered surface, the top part of the camera is replaced by a special attachment, incorporating a metallographic microscope with long-focus objectives (f = 15-16 mm, magnification 300). In the camera is a fitting for fixing and heating the specimens.

Sputtered specimens which are not put under stress may be of any shape. The preferred size of the specimen is 30 x 30 x 8 mm. The best sputtering of specimens occurs at a pressure of 1 x 10^{-1}-1 x 10^{-2} mm Hg in a current of inert gas. The necessary pressure in the working camera is adjusted by varying the rate of admission of the inert gas and by regulation of the pumping limit.

The apparatus was used for ionic etching of two forms of SAP with different oxide contents (SAP-1 and SAP-2), produced by two technological modifications (sintered at 620 and 670°C), and deformed with a different total degree of deformation (70 and 98%). Cathode sputtering of the specimens was carried out in neon under the following conditions: voltage at the specimen 1.5 kV, current density 5 mA/cm², sputtering time 3 h.