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On increased energy and diffusion permeability of ternary grain joints in metal polycrystals

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The estimations made in the work show that the grain boundary areas adjacent to ternary grain joints and having an increased energy and diffusion permeability are extended enough, thus allowing to consider the whole grain connection area adjacent to a ternary joint as a volume defect.

Выполненные в работе оценки показывают, что участки межзеренных границ, примыкающих к тройным стыкам зерен и обладающие повышенной энергией и диффузионной проницаемостью, являются достаточно протяженными, и это дает основание считать всю область сопряжения зерен, примыкающую к стыкам, объемным дефектом.

The ternary joints (TJ) of grain boundaries (GB) are among defects influencing most heavily the set of physico-mechanical properties of polycrystals [1–3]. The data on their static structure and its evolution under various external factors are still insufficient to date.

For TJ, as well as for grain boundaries, the concept of the full joint superposition lattice (TJ FSL) has been proposed; this lattice is constructed on minimum difference vectors of full superposition gratings included in the boundary joints [4]. The main condition for connection of three boundaries consists in that the sum of the translation vector shifts (when a point is turned) at the TJ line should be zero. Thus, the connection condition of boundaries in the joint includes that of grain boundary defects (GBD) contained in the boundaries in contact. There are common sites in the joint FSL, the set of those sites forms a 3D lattice coincident with the crystal lattice of one of grains in the joint. Therefore, the lattice dislocations can dissociate into GBD complexes of any of joined boundaries. This is of great importance for this work.

Strictly speaking, the general type TJ where boundaries of different periodic potential relief are connected cannot be related to linear defects. The stresses arising in this connection become relaxed inevitably from the joint to the region of joined grains having lower elastic modulus as compared to the grain volume. Therefore, the boundaries have an increased energy in areas adjacent to TJ [5], as it was determined using the matching facets. In the materials studied (Al, Cu, Nb), their length was 5 to 150 μm.

The studied using field ion microscopy have shown that the distortion region from the general type TJ in tungsten is of small extension [6, 7]. Such areas of the preferred field etching are somewhat extended along the grain boundaries being narrowed as the distance from the TJ increases; already 1 to 1.2 nm from the TJ those reach the width typical of the grain boundary etching. These data evidence that in tungsten, the general type TJ are linear defects characterized by atomic arrangement distortions localized within a cylindrical region having the average cross- section radius of (1.1 to