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# Features of high-temperature structure evolution in the ZEK100 magnesium alloy

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Magnesium alloys are widely used in the aviation, rocket and automotive industries due to their exceptional mechanical properties. Of great interest among magnesium alloys is an alloy of the Mg-Zn-Zr ZEK100 group, which has a small mass fraction of alloying elements, low forming temperature and good ability to withstand both static and fatigue loads. Alloy ZEK100, like all magnesium alloys, is prone to brittle fracture due to magnesium's characteristic hexagonal structure. However, the brittle fracture of this alloy is also affected by the presence of hard and brittle intermetallic particles along the grain boundaries. These particles strongly influence the macroscopic properties of the alloy, leading not only to brittle fracture, but also, depending on the distribution of these particles, to a significant hardening of the alloy.

An analysis of literature sources showed that the grain boundary wetting phase transitions (Fig. 1) in the ZEK100 alloy have not been previously studied. Thus, the purpose of this work was to investigate the wetting phase transition in the ZEK100 magnesium alloy. In the course of this work, sample preparation, annealing in the temperature range where a liquid phase exists, and metallographic preparation of annealed samples were carried out. The structure of the annealed sample was analyzed using a Versa 3D FEI electron microscope, and the microhardness was studied using the Vickers method.

Based on the data obtained, the fraction of wetted grain boundaries and the average hardness of the phases that make up the structure of the sample were calculated. During the study, the existence of a grain boundary wetting phase transition in ZEK100 magnesium alloy was proved, and the temperatures at which it occurs were determined experimentally. It was found that most of the alloying elements are concentrated in the intermetallic phase at the grain boundaries, which has a significantly higher hardness than the magnesium matrix phase.

According to the results obtained, while the hardness of the magnesium matrix phase does not depend on temperature, and the distribution of the intermetallic phase varies with the annealing temperature, changes were found in the mechanical properties of this alloy, up to its brittle fracture under the action of quenching stresses with a large proportion of wetted grain boundaries.

Thus, we can state that it is the morphology of the arrangement of grain boundary phases that has a significant effect on the overall mechanical properties of the alloy. In other words, knowledge of the nature of the wetting phase transition at the grain boundaries makes it possible to control the structure of the alloy to achieve the required properties. Further study of phase transformations at interfaces in metals, in particular, in cast magnesium alloys, is a promising area of science.



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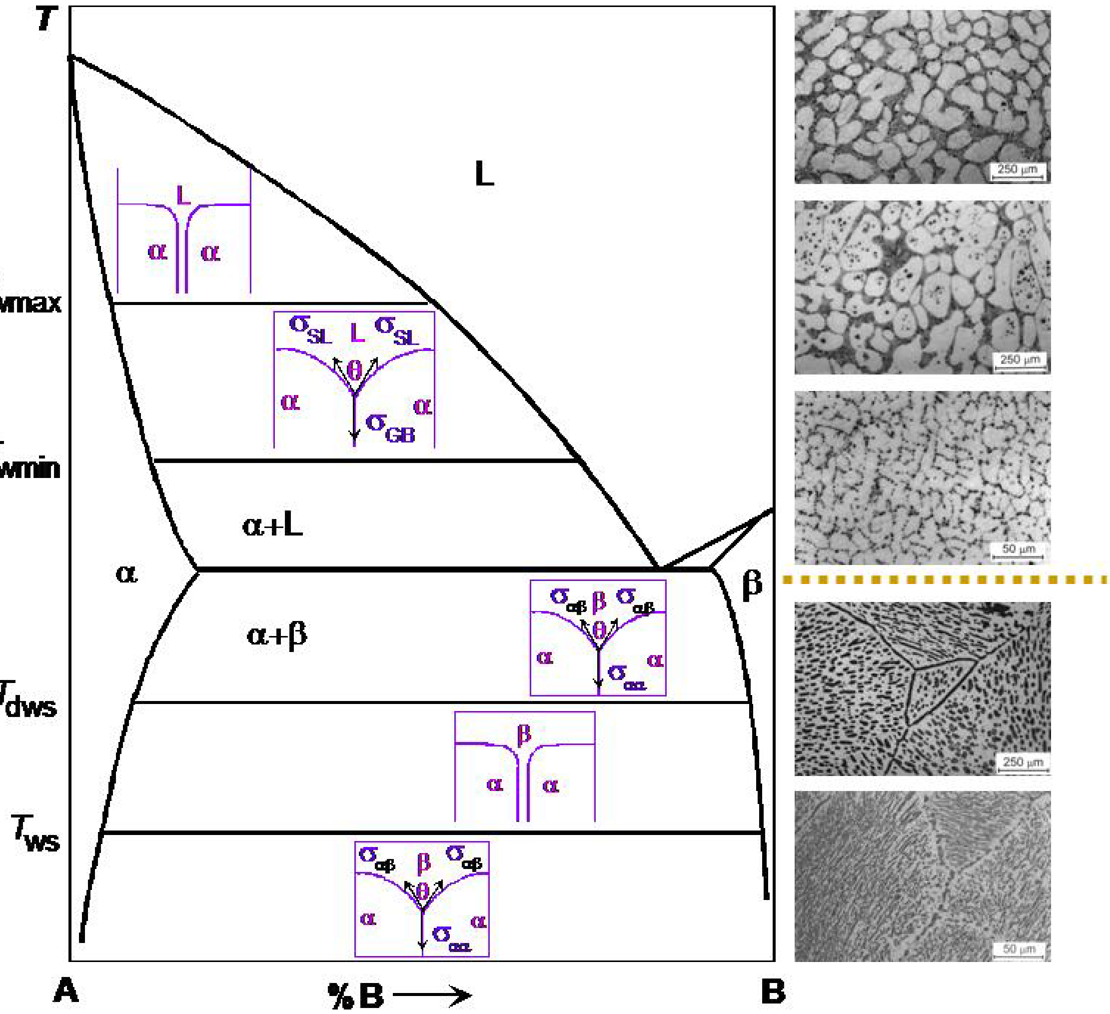


**Fig. 1.** Schematic binary phase diagram illustrating the GB wetting phenomena. Bold solid lines show the bulk phase transformation. Thin solid lines show the tie-lines for the GB wetting by the melt at $T_{wmin}$ and $T_{wmax}$ as well as by the second solid phase at $T_{ws}$ and $T_{dws}$. Schemes between solidus and liquidus lines show the cases of complete (top) and partial (bottom) GB wetting by the liquid phase L. Schemes between solvus lines for α- and β-phases show the cases of complete (middle) and partial (top and bottom) wetting of the α/α GB by the second solid phase β. Micrographs on the right-hand side of the diagram (above the dotted line) show the microstructure for the Al–Mg samples annealed above $T_{wmax}$ (top micrograph, all GBs are completely wetted), between $T_{wmin}$ and $T_{wmax}$ (middle micrograph, some GBs are completely wetted and other GBs are partially wetted) and below $T_{wmin}$ (bottom micrograph, no completely wetted GBs). Micrographs on the right-hand side of the diagram (above the dotted line) show the microstructure for the Al–Zn samples annealed above $T_{ws}$ (top micrograph, all Zn/Zn GBs are completely wetted by the solid (Al) phase) and annealed below $T_{ws}$ (bottom micrograph, all Zn/Zn GBs are partially wetted by the solid (Al) phase). Scheme is reprinted with permission from Ref. [1]. Copyright 2023 MDPI. Micrographs for Al – Zn alloys are reprinted with permission from Ref. [2]. Copyright 2004 Elsevier.

## References


[1] B.B. Straumal, A. Korneva, G.A. Lopez, A. Kuzmin, E. Rabkin, G. Gerstein, A.B. Straumal, A.S. Gornakova. Grain boundary wetting by a second solid phase in the high entropy alloys: a review. Materials 14 (2021) 7506.

[2] G.A. López, E.J. Mittemeijer, B.B. Straumal, Grain boundary wetting by a solid phase; microstructural development in a Zn–5 wt.% Al alloy. Acta Mater. 52 (2004) 4537–4545.