Synergistic Effects in Magnesium-Rare-Earth-Zinc Alloys - A Gateway to Informed Alloy Design

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Abstract

The importance of solute effects and synergies to texture development in high performance Magnesium alloys is now well established. Therefore, attaining a deep understanding of solute interactions is essential for future alloy design. We aimed at unraveling the origin of off-basal texture components in ternary Mg-RE-Zn alloys, regarding solute-grain boundary interactions and synergistic solute effects. To connect microstructural features to the effect of solutes on grain boundaries and slip activation, a multi-scale approach featuring classical EBSD analysis, mechanical testing, atom probe tomography and ab initio calculations was employed. A unique ±40◦ transverse direction (TD) recrystallization texture was observed in Mg-Gd-Zn and, notably in Mg-Er-Zn. This texture component was attributed to the early stages of recrystallization. Both distinct nucleation sites and selective growth were proven important to the survival of off-basal texture components in the final texture. Atom probe and slip trace analysis in ternary Mg-RE-Zn alloys revealed that the solute ratio rather than the absolute solute concentrations governs segregation and deformation modes. This underscores the importance of synergistic effects to the final texture and suggests the possibility to control it through solute ratios, offering a pathway towards tailored texture design. A comparison of RE to Ca solutes, demonstrated beneficial texture alterations in Mg-Ca alloys. However, in RE containing alloys, synergistic solute effects were found to be predominantly effective, compared to Mg-Ca-Zn. Further investigations by atom probe tomography and ab initio calculations identified significant differences in binding energies and segregation behavior of Ca and Gd. These findings collectively highlight the role of synergistic effects in texture evolution and encourage further research towards targeted texture design.

Keywords: texture, magnesium rare, earth alloys, solute segregation, grain growth, recrystallization

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