Multiscale Phase-Field Modeling of Mg-Al Alloys Eutectic Solidification

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Abstract

Due to it's low density, Mg-Al alloys are of high importance for modern lightweight structures and are widely used for various application in automotive and aerospace industries as well as consumer electronics. The properties of Mg-rich Mg-Al alloys are primarily determined by their micro-structure which consists of two main phases: the Mg-rich HCP-alpha-Mg-phase and a near stoichiometric $Mg_{17}Al_{12}$-beta-phase.

The addition of Al has positive effects on the corrosion propperties of low-alloyed Mg-Al due to the formation of the beta-phase. Experiments reveal that the formation of a closed shell of beta magnesium, preventing alpha-dendrites from building networks, is a good strategy to severely hinder the galvanic corrosion associated with the use of Mg-alloys in contact with more noble metals. Thus tailoring of the Mg-Al alloy microstructure is of great importance for controlling its corrosion resistance.

We present simulations of the nucleation and equiaxed dendritic solidification of the primary Mg-HCP-alpha-phase followed by the nucleation and growth of a secondary beta-phase in interdendritic regions. The details of the $Mg_{17}Al_{12}$-beta-phase formation in the melt channel is closely investigated. These simulations help to predict the properties of the final alloy based on the process parameters and increase understanding of the solidification process, which enables the design of Mg-Al alloys for different applications.