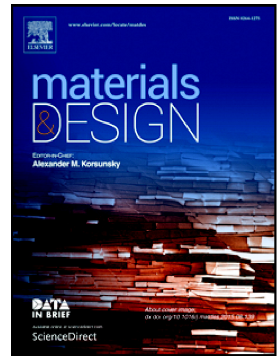

Thermodynamic description of the quaternary Al-Si-Mg-Sc system and its application to the design of novel Sc-additional A356 alloys

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Thermodynamic description of the quaternary Al-Si-Mg-Sc system and its application to the design of novel Sc-additional A356 alloys

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Abstract:

Using published experimental phase equilibria, a self-consistent thermodynamic database of the Al-Si-Mg-Sc quaternary system in the Al-rich corner was established by application of the CALPHAD (CALculation of PHAse Diagram) technique. The reliability of the thermodynamic database was tested in two quaternary model cast alloys by comprehensive comparison of their experimentally measured solidified microstructure characteristics and phase transition temperatures with the calculated ones. Scheil-Gulliver simulations were performed, allowing construction of a solidification diagram for Sc-added A356 alloys to examine the influence of Sc levels on the solidification behavior of cast A356 alloys. With the aid of theoretical solidified microstructure analysis and its qualitative relationship with mechanical properties, the optimal amount of added Sc in A356 alloys was determined to be 0.54 wt.%. The experimental mechanical property measurements and microstructural characterizations confirmed that the A356-0.54 wt.% Sc alloy exhibits the best comprehensive mechanical performance. Additionally, the grain refining mechanisms in Sc-supplemented A356 alloys were described, suggesting a path for further improvement of the overall mechanical performance.

Keywords: Cast aluminum alloys; CALPHAD; Thermodynamic modeling; Grain refinement; Mechanical property