Influence of a rotating magnetic field to the microstructure of directional solidified Aluminum – Silicon alloys
– comparison of experiment and simulation –

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ABSTRACT

The objective of the European MICAST [1] project is to systematically investigate the formation of microstructures during directional solidification of Aluminum alloys under diffusive and controlled convective conditions. In order to control convection time-dependent magnetic fields are used. One part of the work is the development of numerical models able to predict the influence of the rotating magnetic field on parameters of the microstructure, like primary and secondary dendrite arm spacing, on the scale of the sample.

For that purpose the software package CrysMAS, developed at Fraunhofer IISB, was extended using a multi-phase and multi-scale model based on the work of Wang and Beckermann [2].

The model assumes a fixed solid and permeability is calculated by the Carman-Kozeny equation. A tracking algorithm for the columnar growth front was integrated in order to compute the front undercooling and velocity of the dendrite tips. This gives the possibility of calculating the primary [3] dendrite arm spacing on the scale of the sample in 2D-axial symmetric geometries. The influence of fluid flow on the primary arm spacing is taken into account by the model of Lehmann [4]. This arm spacing is also used to calculate the local permeability of the mushy zone.

In order to validate this model, it was applied to the directional solidification of AlSi7 under the influence of a rotating magnetic field (RMF). The calculated results are compared to experiments conducted by MICAST partners [5]. Figure 1 shows a typical example of the calculation results for liquid fraction and macrosegregation in the case that a RMF (magnetic Taylor number Ta_m =550) is applied to a directional solidification process. In Figure 2 a measured radial segregation profile is compared to the calculated values. A good correlation between simulation and experiment is found.

Further on comparisons of the primary dendrite spacing obtained in experiments and simulations will be shown.

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RESULTS

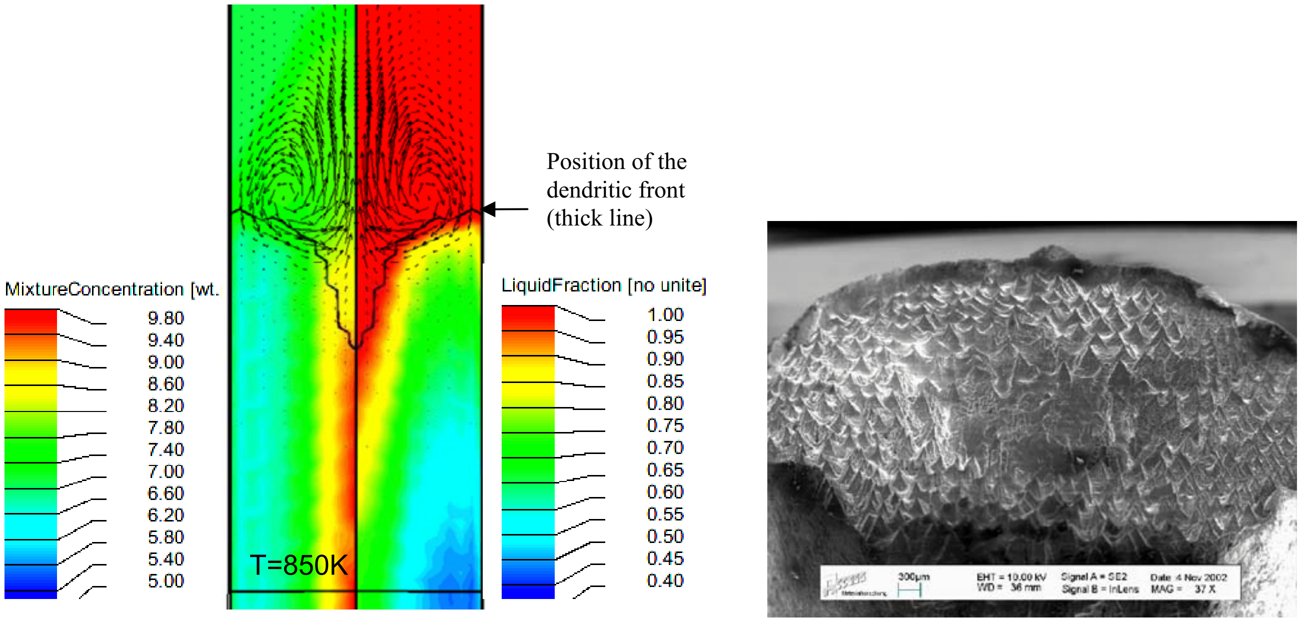

Figure 1: Left: Calculated silicon concentration (left) and liquid fraction (right) during ion solidification of AlSi7 under the influence of a rotating magnetic field (RMF), axial gradient G= 3K/mm, magnetic induction B_0=3mT, growth velocity v_g=0.12mm/s. Decanted sample of A356 solidified with a RMF applied (Source: ACCESS, Aachen)

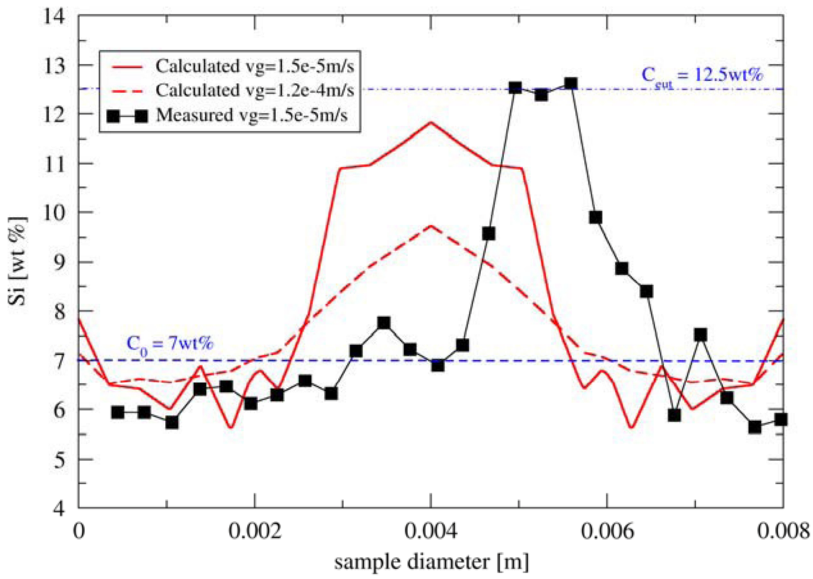

Figure 2: Measured (symbols) and computed radial silicon distribution for samples solidified with RMF applied (gradient G= 3K/mm, magnetic induction B_0=3mT) and several growth velocities v_g.