DFG-Project Schm-746/64-1

Influence of interdendritic solidification voids on the mechanical properties of Al-alloys

Begin of the Project: 01.11.2007
End of the Project: 31.07.2010

Aim

In this project, the crystalline structure during solidification process and the micro voids are simulated independent of the process parameters like cooling rate, temperature gradient and the composition of the alloy. Through a direct discretization of time and space, one obtains not only the information about the growth kinetics of the voids, but also the voids' form and their position in the structure.

The goal is to investigate the influence of interdendritic solidification voids on the macro-mechanical properties of an Al-Si-Mg alloy based on the simulated microstructure in the framework of a multiscale modeling. To evaluate the material properties and to validate the simulation results, experimental tests should be performed on the reference samples with defined alloy composition and producing parameters.

Basic Material

A pure Aluminum-Silicium cast alloy (Al-7%Si-0.3%Mg) is investigated as the basic material. The fracture strength and the mechanical properties of the Si-contained Al-based materials are determined by density, size, form, orientation and distribution of micro voids, the secondary dendritic arm spacing as well as by the density and distribution of secondary precipitates.

Methodology

The specific questions are which influence the distribution of the micro voids in the structure has on the local (crack initiation and crack propagation) and macroscopic failure behavior in the framework of a multiscale modeling. For this purpose, it is to be beforehand determined how the cellular or dendritic solidification structure affects the voids' distribution. The methods, which should be applied for this end, are the phase field simulation including analytical methods plus the micromechanical and macromechanical FE-modeling including the damage simulation.

Figure 1 depicts the comparison between the calculated Al-cast structure with a micro-image of an Al-based piston cast alloy.

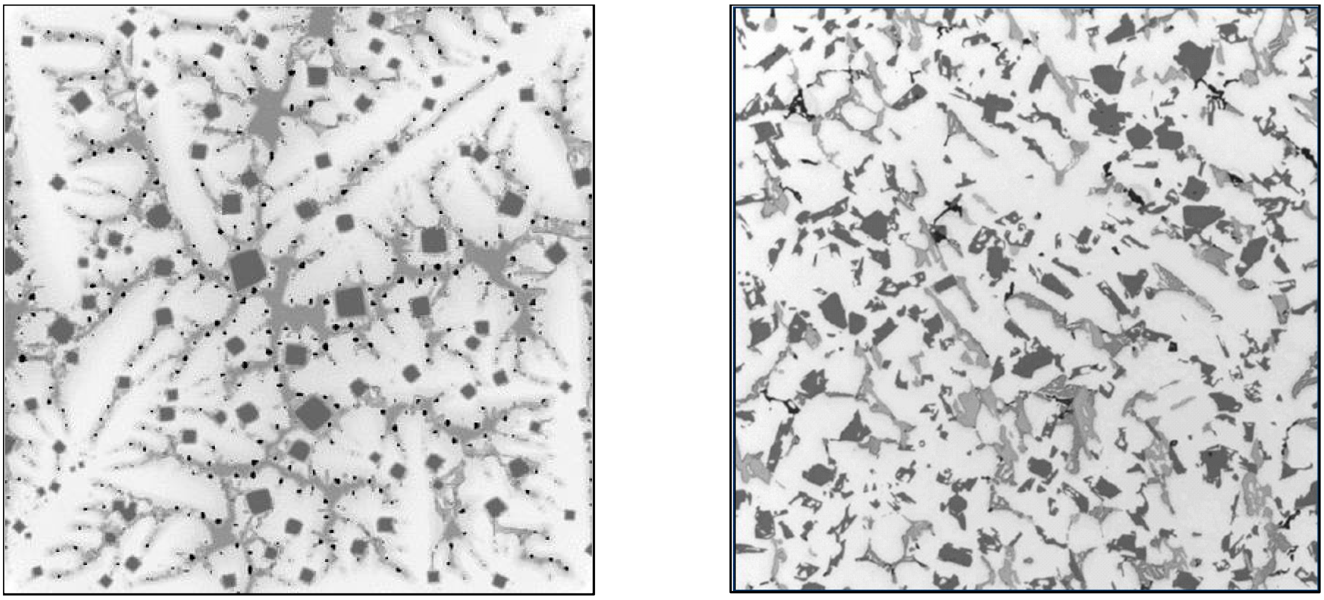

Figure 1: Left: Calculated Solidified Structure (~90% solid) of a 5-component Al-cast alloy (Al-Mg-Si-Ni-Cu), sample size 800µm. Right: Micro-image, Main parts of the grain structure are the primary Al-Dendrites as well as Al-Si-Precipitates

A micromechanical structural simulation would be performed based on the real and simulated distribution of voids. The basic principle of the micromechanical simulation creates the representative 3D-real micro model (Figure 2). Thus, the crack propagation is simulated at the microstructural level and the influence of the voids is analyzed.

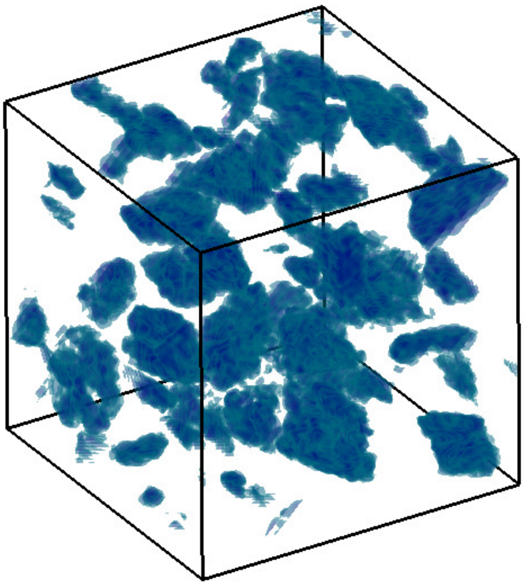

Figure 2: Real microstructural depiction (Voxel representation) of an Al/15vol.%Al_2O_3-composite materials (only ceramic parts are visible).

Partner

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At Access, the microstructure and the corresponding element and phase distributions as well as the size, form location and distribution of the micro voids are determined in the microstructure via the use of phase field modeling.

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