DFG-Projekt Schm 746/64-2

The effect of interdendritic solidification pores on the mechanical properties of AlSi-cast alloys

Project begin: 01.02.2012
Project end: 31.01.2015

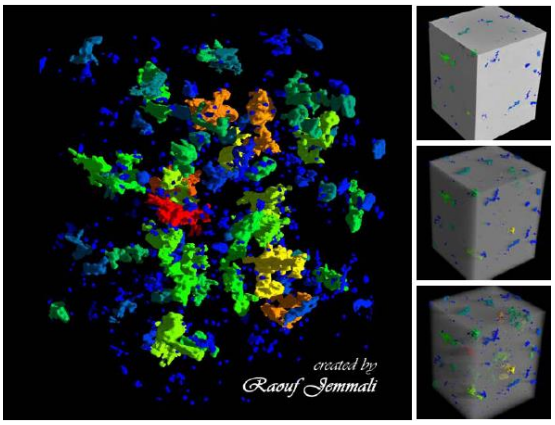
Aims

This proposal is the extension of the joint project DFG Schm 746/64-1 and AP 196/1-1 „The effect of interdendritic solidification pores on the mechanical properties of Al-7%Si-0.3%Mg-Alloys“. Our aim is now to combine and extend the computational models developed in the previous period to allow a comprehensive simulation of microstructure and porosity formation together with the analysis of the mechanical properties on the relevant length scales. To this end, the phase field method for the microstructure predictions, including porosity formation, finite element simulations of fracture behaviour based on the embedded cell model (real microstructure) and cohesive zone elements, the element elimination technique for the prediction of the mode of fracture and the crack path propagation, taking into account the particular microstructure, will be combined. We will concentrate on the effect of interdendritic “micropores” (d ≈ 20 µm) rather than bigger (up to d ≈ 400 µm) intragranular pores

Methods

For the investigations of the influence of microporosity the following methods are used: metallographical investigations, tensile testing and fracture experiments as well as phase-field method simulations for microstructure formation and FEM simulation for simulations of mechanical behaviour:

Tomographical investigations



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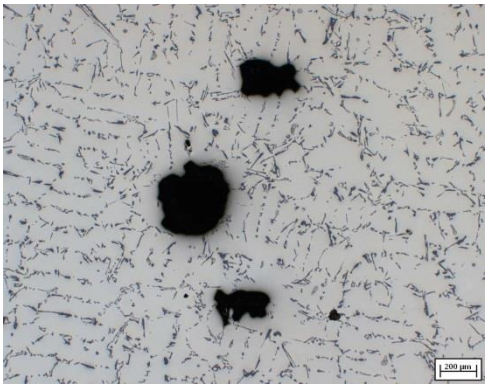
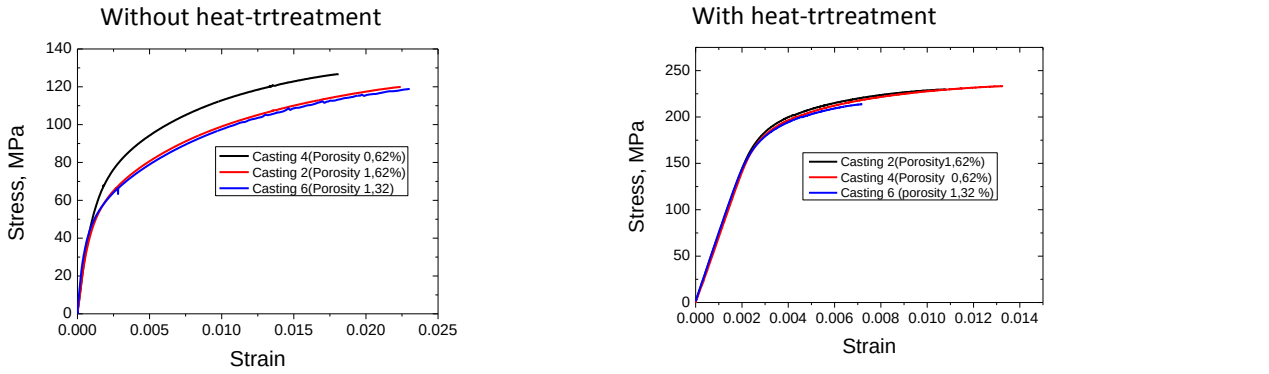
Metallographical investigations



Both tomographical and metallographical surface characterization testifies to the existence of small pores (diameter around 20 mm) and big pores (200-400 mm).

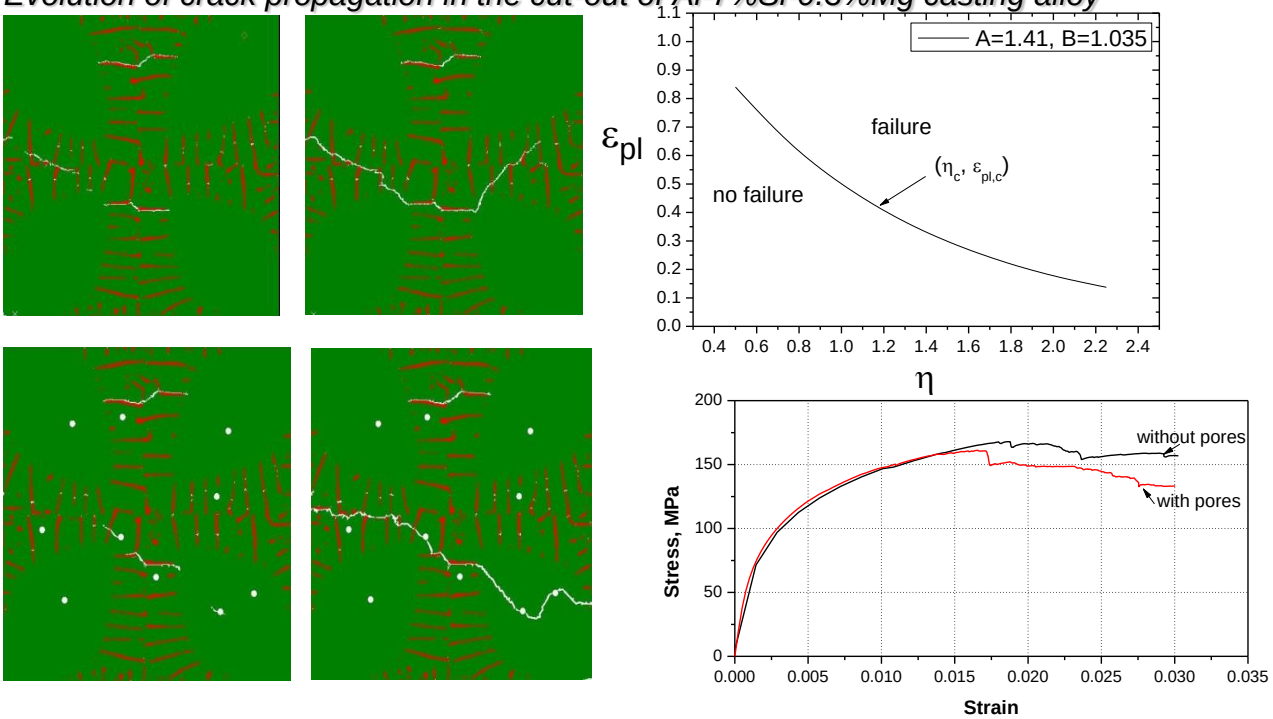
Tensile test experiments



Tensile test experiments show that after heat treatment the strength significantly increases but ductility decreases, the stress-strain curves differ by failure strain

FEM-simulations of crack propagation in microstructure with Element Elimination technique

Evolution of crack propagation in the cut-out of Al-7%Si-0.3%Mg casting alloy

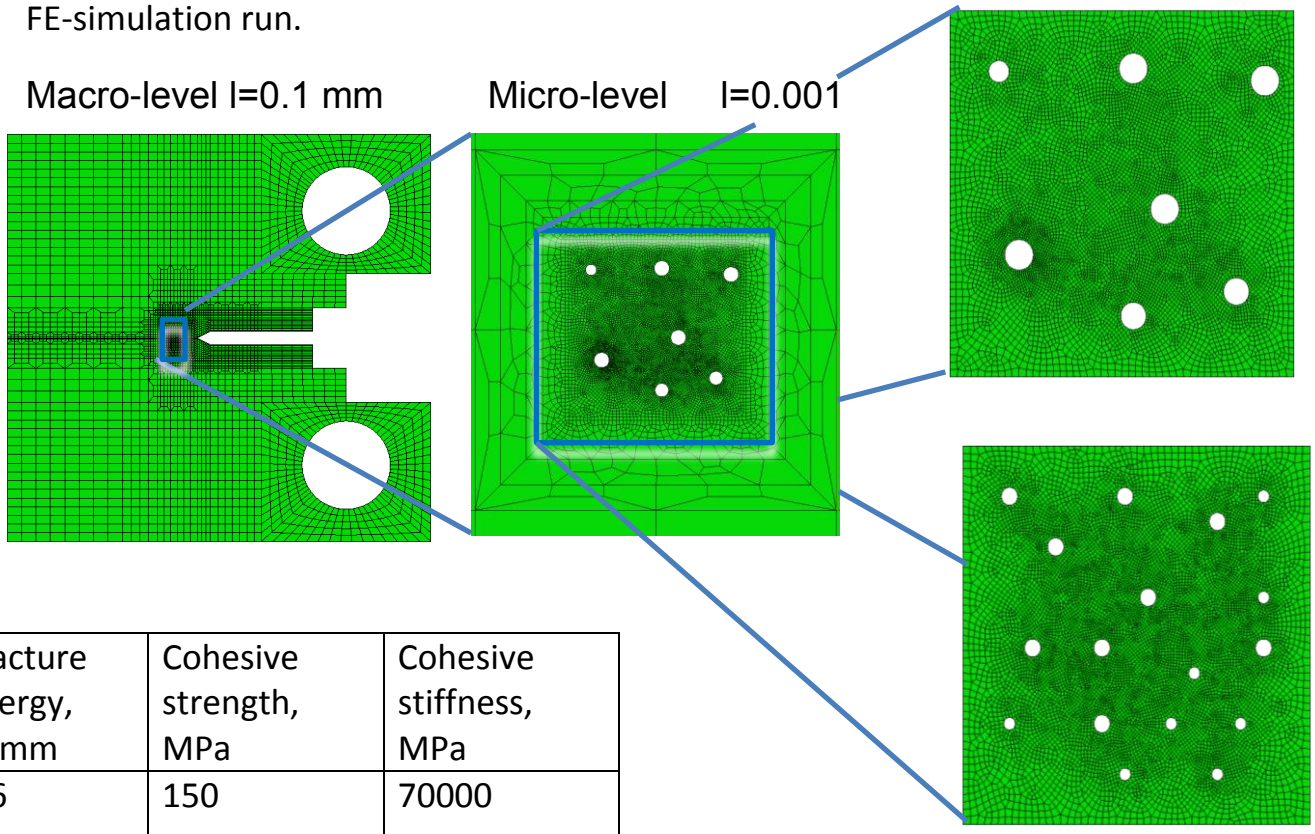


Porosity effects the crack propagation in microstructure deviating the crack from its initial path at the later stages of simulations and the stress-drop on stress-strain curve is clearly pronounced in the microstructure with porosity**.**

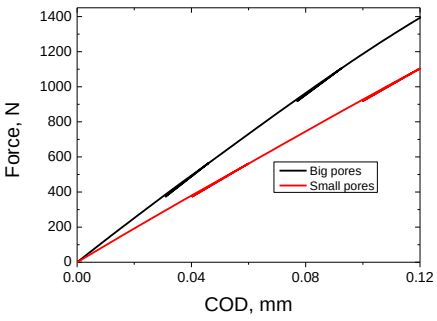
G. Lasko, M. Apel, A. Carre, U. Weber and S. Schmauder, Adv. Eng. Mat. **14**, pp. 236-247 (2012)

Combined simulations of C(T)-test on macro- and micro-level

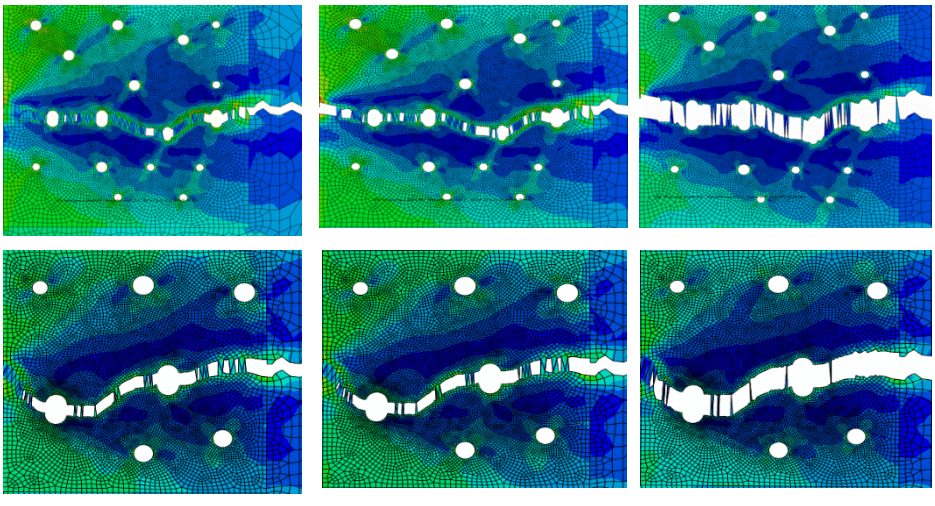
For the investigations of the size of micropores on the crack path in cut-out of microstructure the cut-out of microstructure with the same volume fraction of porosities but different pore sizes have been considered, by embedding the piece of microstructure in macro- compact tension test specimen and simulations on both scale levels have been perfo Micro-level l=0.001rmed in one FE-simulation run.



Fracture Energy, N/mm	Cohesive strength, MPa	Cohesive stiffness, MPa
3.6	150	70000



F-COD curve matching the instance of crack entering the cut-out of microstructure



The results obtained within the project have been presented at the following conferences

1. ICCE-21 Tenerife, Spain July 21-27, 2013
2. International Conference 'Hierarchically built systems of orgenic and inorganic nature, September 9-13, 2013

Acknowledgement

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