Multiscale experimental and numerical investigation of the behavior of a cast aluminum alloy

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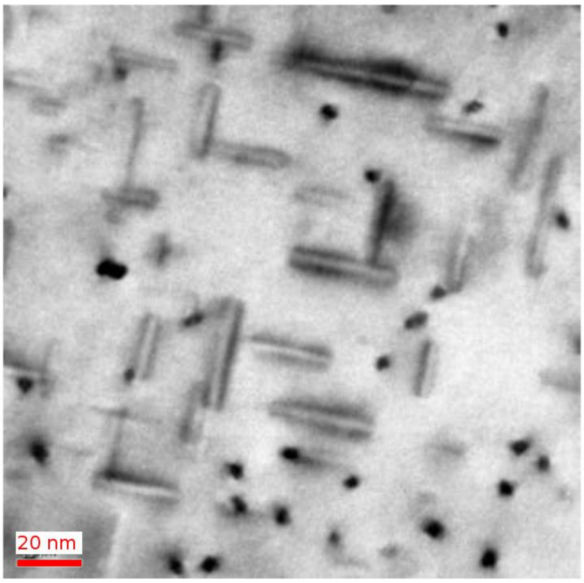

- Modeling precipitation kinetics in A356 + 0.5Cu type aluminum alloys
- Accounting for different simultaneously precipitating phases and the effect of precipitate morphology
- Development of a micro-mechanics model to predict the evolution of yield strength
- Application in the prediction of the effect of heat treatment parameters on mechanical properties

Abstract:

There is currently significant interest in understanding precipitation reactions in casting alloys which are used for cylinder heads. In this work, the precipitation of β-Mg_2Si particles in an A356+0.5 Cu cast aluminum alloy is addressed. Consideration of its simultaneous precipitation alongside θ-Al_2Cu phase is incorporated.
The theoretical approach taken enables the simultaneous treatment of nucleation, growth and coarsening. The model is based on the framework of the KWN method and uses an implicit finite difference scheme. The continuity equation is discretized in time and space in order to obtain a matrix form. The KWN model is directly coupled to the CALPHAD software (Thermo-Calc) which provides data on the driving force for precipitation and the evolution of local equilibrium value for the solute concentration at the matrix/precipitate interface, taking into account the Gibbs-Thomson effect. Simulations with software can be used to provide quantitative predictions on the impact of the cooling rate and age-hardening heat treatments on the size distribution of particles. The results of the model have been validated by TEM measurements.
A micromechanics model then takes in size distributions of particles to provide a prediction of yield strength of the material.
This kind of multiscale approach provides new perspective on microstructure evolution for highly loaded components such as cylinder heads, i.e. it enables a more accurate prediction of the microstructure and its evolution as a function of thermal history.