INTERDISCIPLINARY CENTRE FOR ADVANCED MATERIALS SIMULATION

ICAMS Seminar

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Monday, October 17, 4:30 p.m. ICAMS Seminar room UHW 11/1102

Supersaturations and their role in phase transformations

Supercoolings or superheatings are frequently put forward to be driving forces for phase transformations. Changes in Gibbs free energy are a direct function of supercooling/ superheating in pure substances, or, equivalently, of supersaturation in alloys or other mixtures consisting of several components.

In some cases, the role of supersaturations as a basis for phase transformations is well understood and can be quantitatively incorporated in phase transformation models. Examples are precipitation of finely dispersed particles from a solid supersaturated solution, or solidifi-cation from an undercooled liquid. The understanding of such processes is used in numerous instances to optimize microstructures for a given application.

In other cases, supersaturations are undesirable but inevitable during processing of a material; their consequences can be drastic and detrimental for the material's properties. Examples are the structure evolution of alloys that feature a retrograde solidus line (see fig. 1), or the embrittlement of alloys with varying temperature dependence of solubility (fig. 2).

In the present work it is shown that the mass transport in the phases taking part in a phase transformation, particularly the difference in kinetic coefficients, plays a major role as far as the predictability of phase transformation kinetics is concerned. Experiments on solutal melting have shown that 'classical' theories of phase transformation can safely be applied to phase transformations where the supersaturation is achieved in the phase in which the faster mass transport kinetics occurs. In the reverse transformation, i.e. when supersaturation is achieved in the phase with the slower mass transport kinetics, an extension of theories describing the kinetics of the phase transformation is necessary. With the extended theory, a larger variety of phase transformations can be modeled quantitatively.

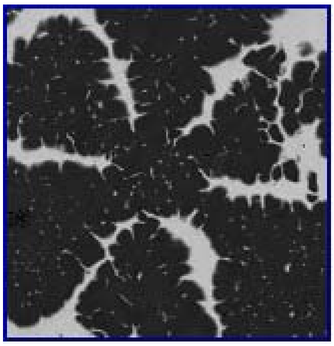

Fig. 1. Microstructure of an alloy from a binary alloy system that features a retrograde solidus line (Ag-Bi); primary dendrites were partially remelted due to supersaturation occurring upon cooling.

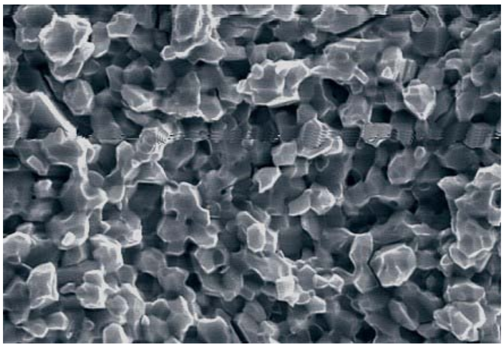

Fig. 2: Fracture surface of a solder alloy wire of Zn-Al-Ga, after extrusion embrittled due to supersaturation that occurs in the fcc (Al) phase.