MEASUREMENT OF THE METASTABLE LIQUIDUS OF DELTA-FE-CO SOLID SOLUTIONS AND ITS IMPLICATIONS FOR THE FE-CO PHASE DIAGRAM

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Melt undercooling experiments have led to new measurements of the metastable liquidus in the Fe-Co system [1] which are unobtainable by other methods. The implications of these measurements on Fe-Co phase diagram calculations are considered.

Electromagnetic levitation (EML) is a technique which allows a molten droplet of an alloy to be undercooled by as much as 300 K below the liquidus. The temperature of the sample is monitored by an infrared pyrometer and a Si diode (with a sampling rate of 2 MHz) which allows details of the rapid solidification and subsequent recalescence to be resolved. The alloys, Fe-30Co, Fe-40Co and Fe-50Co (atomic percent) were levitated and undercooled to various degrees. In each of the alloys, below a critical undercooling, the recalescence curves changed from a single to a double step, indicating the formation of a metastable phase and its subsequent transformation to the equilibrium (FCC) phase. It is widely believed that the metastable phase obtained by such experiments in the Fe-Co system is BCC delta-Fe-Co. Thus the temperature at which the BCC phase transforms back to the FCC phase can be taken as a measure of the liquidus of the BCC phase.

A thermodynamic database for Fe-Co was constructed from parameters available in the literature [2-4]. The parameter describing the entropy contribution to the free energy of BCC Co and the enthalpy term of the interaction parameter for BCC Fe-Co were adjusted so that the liquidus line of delta-Fe-Co fitted to the experimental points. The two parameters that were changed were previously determined only from optimisation. The adjustment was carried out so that phase diagram was kept close to the original version.

Thermo-physical parameters such as the free energy and entropy of various phases over a range of temperature were extracted from the adjusted database. The free energy of formation of a spherical nucleus of a critical size (delta-G-star) was then calculated according to classical nucleation theory. For all three of the alloys studied here, the FCC phase had a more negative delta-G-star at temperatures just below the equilibrium liquidus and is therefore the preferred phase for nucleation. As the temperature decreased further below the equilibrium liquidus (i.e. higher undercooling), a transition was shown for all three alloys in which the BCC phase had a more negative delta-G-star. This indicates that the formation of a BCC spherical nucleus of a critical size should be preferred for nucleation within a given temperature range. This temperature range was compared with the critical undercooling measured in the experiments and good agreement between the two was found.

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