

ON REPRESENTATION OF THE GP ZONE SOLVUS IN Al-Ag ALLOYS

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The Guinier-Preston (GP) zone solvus in Al-Ag alloys has a curiously complex shape (1). Recently, two groups of investigators re-examined experimentally the low temperature region of the Ag-rich portion of this solvus (2,3). Both groups pointed out significant differences between their experimental data and the predictions of the modified regular solution model which had been employed in order to represent the high-temperature and low-Ag regions of the GP zone solvus (4). Our thermodynamic model was produced in order to interpret observations made on the faceting of GP zones in an α -solid solution Al-Ag alloy (4). In developing this model, account was taken of both the shape of this curve and thermodynamic data available on α -Al-Ag solid solutions (5). However, it was understood in advance that this model would be incorporated into a system of non-linear difference equations, whose solution was already known to be quite time consuming, even when the standard regular solution model is employed (6). Simultaneous solution of these equations yielded the concentration-penetration curve through the coherent, hence compositionally diffuse (7), α :GP zone interface. These data were then used to compute the α :GP zone interfacial energy (6), from which the polar γ -plot, and thence the Wulff construction were obtained as a function of temperature. Given the small size of GP zones, the short average distance between adjacent zones, the relatively high diffusivity operative and the small misfit between the zones and the α matrix, the Wulff or equilibrium shape should be a fair representation of the shape developed by the zones.

As shown in Fig. 1, the GP zone solvus in α -Al-Ag departs very far indeed from that of the symmetrical miscibility gap corresponding to the standard regular solution model. The problem thus facing us was the construction of a new model which would reproduce the GP zone solvus with reasonable accuracy without making the difference equations so cumbersome that construction of an accurate polar γ -plot would require an inordinate expenditure of computer time. Fortunately, the experimental data on the faceting of GP zones had been obtained at and above 433 K. Hence it was sufficient to attempt an approximate description of only that portion of the solvus lying at less than 40 at% Ag. The modified regular solution model developed is seen to be sufficiently accurate in the temperature-composition regime of interest. Of course, when the solute-rich portion of the calculated curve is extended to lower temperatures there is a marked departure from the experimentally determined solvus. While the modified regular solution model yielded better agreement between the calculated and observed shapes of the zones, this model is sufficiently complex that calculation of the interfacial energy in high index directions, particularly at higher temperatures, became prohibitively time-consuming. A model which could reproduce the GP zone solvus throughout the temperature range shown in Fig. 1 would likely be so intricate that calculation of interfacial energy even in low index directions would require the use of an exceptionally powerful computer.

In the version of Fig. 1 presented (as Fig. 8) in the original paper (4), we drew the Ag-rich portion of the calculated GP zone solvus down to 200 K, far below its intended range of applicability. By terminating the calculated Ag-rich solvus at 430 K in Fig. 1 we hope to discourage such comparisons from being repeated at lower temperatures by other investigators. Indeed, no claim was made that our model is of exemplary accuracy even at higher temperatures in the Ag-rich region (4). We re-emphasize that we simply used a compromise, empirical model in an attempt to account for our measurements on faceting of Al-Ag GP zones at high temperatures within the limitations of the computer system available to us at the time. Hence this model is unsuitable for exact delineation of the GP zone solvus in the Al-Ag system.

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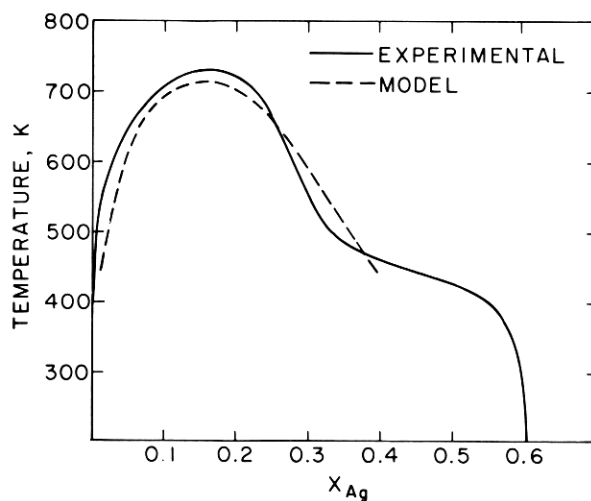


Figure 1: Comparison of the experimental and theoretical GP solvi in the Al-Ag system. Adopted from (4).