ON THE STABILITY OF THE MARTENSITE IN β-CU-ZN ALLOYS.

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Pergamon Press

NEW YORK • OXFORD • TORONTO • BRAUNSCHWEIG

Scripta METALLURGICA Vol. 8, pp. 213-216, 1974 Pergamon Press, Inc.
Printed in the United States

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(Received December 28, 1973)

The CuZn alloys are representative of the so called "electron compounds". In these alloys the stability of the different equilibrium phases is controlled mainly by the electron concentration e/a (1). No such correlation has however been found between e/a and the temperature M_s at which the ordered body centered cubic βCuZn transforms martensitically to a new phase on cooling (2). This means that other factors than e/a control the concentration dependence of M_s of the martensite phase. In this note it is shown that a good correlation exists between M_s and the tetragonality of the martensite structure in binary and ternary alloys based on the CuZn system.

In the CuZn alloys the martensite has a faulted orthorhombic ABCBCACAB structure often containing thin lamellae of a face centered or a hexagonal phase (3). The structure can be considered formally as having a faulted face centered lattice. By X-ray investigations it has been shown that the face centered lattice is distorted tetragonally (4), its axial ratio c/a being composition dependent. The c/a for different compositions in the ternary system can be calculated if c/a is known for a few alloys, since in the ternary diagram the lines of constant c/a are parallel (4). Be c_{Zn} and c_X the concentration in atomic percent of zinc and the third element X, and be $f_\delta = c^b_{Zn}/c^b_X$ the ratio of the zinc concentration in the binary CuZn and the X-concentration in the binary CuX system for the same c/a. Then c/a is a unique function of $f_\delta c_X + c_{Zn}$. For binary CuZn,

ternary CuZnAl and CuZnGa published values of the splitting between the (202) and (132) X-ray peaks were used to calculate c/a (4,5,6).

In figure 1 is plotted c/a versus $f_o c_X + c_{Zn}$, taking as best fitting value $f_o = 1.355$ for X = Ga and Al. For the CuZnSi system f_o was obtained from figure 4 of the paper by Delaey and Cornelis(7), i.e. a value of $f_o = 1.70$. In figure 2 is shown M_s versus c/a for the binary CuZn and the three ternary alloys. The M_s temperatures are taken from (2,8). As is seen all the data lie on a single straight line, the scatter being somewhat larger but of the same order of magnitude as the error of $\pm 6^{\circ}C$ associated with the measurement of M_s as claimed by Pops(2). The alloys whose data are used for the plot in figure 2 have only a small concentration $c_X < 4$ at% of the third element. No data exist that show to what extent the relation between M_s and c/a holds for larger variations in the alloy compositions. It is obvious that an extrapolation to the binary CuAl system is not justified because the measured M_s (9) lies above the line of figure 2. Thus the factor that controls the concentration dependence within a sufficiently small composition range is clearly the axial ratio.

c/a can affect M_s in two different ways: a) A variation in the lattice parameter changes the amount of secondary shear which is required to obtain an undistorted habit plane, according to the Wechsler-Lieberman-Read phenomenological theory (10). Consequently the density of the stacking faults in the martensite phase is concentration dependent. This prediction has been verified experimentally by Delaey and Cornelis (7). A variation in the stacking fault density implies a concentration dependent contribution to the free energy of the martensite even if the "stacking fault energy" is constant. It can be shown however (11), that in order to explain the variation of M_s by this contribution alone unreasonably high stacking fault energies are required. b) The volume free energy is affected by c/a. It is likely that the tetragonality is due to the order which the martensite inherits from the bcc β phase. The reasons are that the tetragonality disappears when order is

destroyed by plastic deformation (12,13),and that neither the disordered equilibrium fcc α phase nor the hexagonal ξ phases which are stable in the similar CuGa and CuGe system show any marked deviations from closepackedness at the electron concentration corresponding to that of the martensitic CuZn alloys (14).Since M_S depends on c/a it is concluded that the free energy contribution of the long range order essentially determines the composition dependence of the free energy difference between the β' phase and the martensite.Thus other contributions like those that depend on the electron concentration remain rather constant in the binary and ternary martensitic CuZn alloys.

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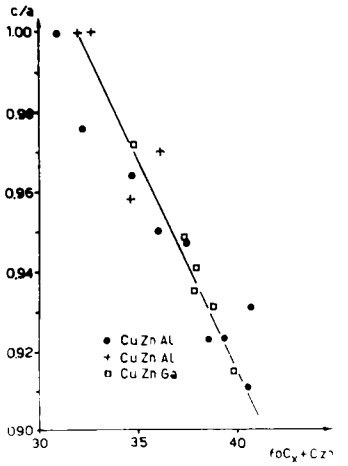

Figure 1

c/a for different ternary systems. c_X and c_{Zn} concentration in at% of third element X and Zn.

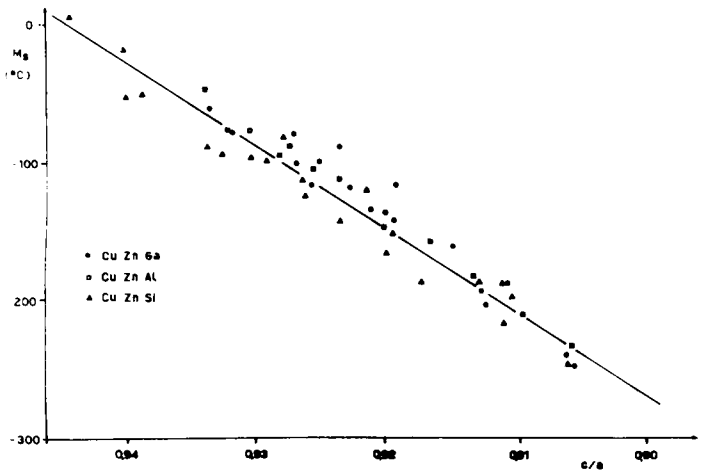

Figure 2

Transformation temperatures M_s for burst type martensite as a function of c/a. M_s data from (2,8).