DOMAIN STRUCTURE OF THE γ_2 PHASE IN THE ALUMINIUM-CHROMIUM SYSTEM

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Of the four γ-brass-like phases which were reported(1,2) to exist in the Al-Cr system between 30 and 42 at.% Cr, only the structure of the γ_2 (Cr_5Al_8)-phase has been determined(3). The unit cell of Cr_5Al_8, as redetermined by single crystal methods(4) is rhombohedral with a_0 = 0.781nm, α_0= 109,13°, and can also be described as a pseudocubic (b.c.) cell with a = 0.906nm and α = 89.28°. The structure of its high temperature form γ_1, which is stable between approximately 850 and 1080 K, is not known. According to X-ray powder patterns all four γ- phases are structurally closely related.

In connection with a systematic study of microstructures in the γ-region of the Al-Cr system we have in a previous paper(5) given an analysis of the regular domain structure of the γ_2-phase with the stoichiometric composition Cr_5Al_8. It has been shown that the observed fragmentation into domains nearly completely relieves the strains caused by the rhombohedral distortion of the original cubic lattice.

In this paper we report on the domain structure of the offstoichiometric γ_2-phase containing 42 at.% Cr.

An alloy with the corresponding nominal composition has been prepared by melting chromium of 99.9% and aluminium of 99.99% purity in an argon-arc furnace. Homogenization, heat-treatment and quenching procedures have been identical as for the stoichiometric phase(5). Specimens for transmission electron microscopy were prepared by jet electropolishing.

The typical microstructure of such a crystal is shown in Fig.1. A high density of planar faults parallel to the beam direction and to the (110) planes is visible. The width of the domains separated by these interfaces is in average less than 0.1μm. It has been shown by diffraction and contrast experiments that these domains are in twin orientations. As can be seen from Figs.1 and 2 these (110) twin domains are crossed by very narrow ribbons with typical width of about 3nm as at X. Some of these ribbons or domains end at dislocations (Y in Fig.1), while other make U-turns where three such ribbons join (U in Fig.1 and 2). Since contrast experiments have shown that these narrow domains are as well in twin relationships with the surrounding matrix we shall call them microtwins to distinguish them from the first ones. Detailed contrast experiments have shown that these faults are imaged with fundamental reflections as α-fringes, and as π-fringes when superlattice reflections are used.

On the basis of these observations it is reasonable to assume that the microtwin separates two domains whose relative displacement is equal to the Burgers vector of a partial dislocation in the lattice. For the cubic γ-phase Morton(6) has determined that they are of the type

$\pm m\langle 110\rangle$ and $\pm n\langle 111\rangle$ with m = 0.35 and n = 0.175. Similar values of m and n should hold for the rhombohedral structure due to it's close similarity to the cubic one. For the $\langle 110\rangle$ direction this is confirmed by the fact that the displacement vector R of two domains separated by a fault was found to be equal to $\frac{1}{3}[110]$.

A schematic drawing of three microtwins (μDv) joining together is shown in Fig.3a, whereas Fig.3b represents the situation marked by X in Fig.1. These drawings show the model for the microtwins which is consistent with the above observations. Namely, the two boundaries of a microtwin are twin boundaries parallel to (110) with the displacements being $\pm\frac{1}{3}[111]_M$ and $\pm\frac{1}{3}[111]_{TW} = \pm\left[\frac{1}{3}\,11\bar{1}\right]_M$ at the first and the second boundary respectively. Such a microtwin can be described as a dissociated antiphase boundary, which is formed due to the energetically favourable dissociation according to the scheme:

$$\frac{1}{3}[110]_M = \frac{1}{6}[111]_M + \frac{1}{6}[111]_{TW} = \frac{1}{6}[111]_M + \frac{1}{6}[11\bar{1}]_{TW}$$

It is believed that the observed domain structure of the nonstoichiometric γ_2-phase can be explained by the fact that combined twin- and non-conservative antiphase-boundaries accommodate offstoichiometric chromium atoms.

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Fig.1

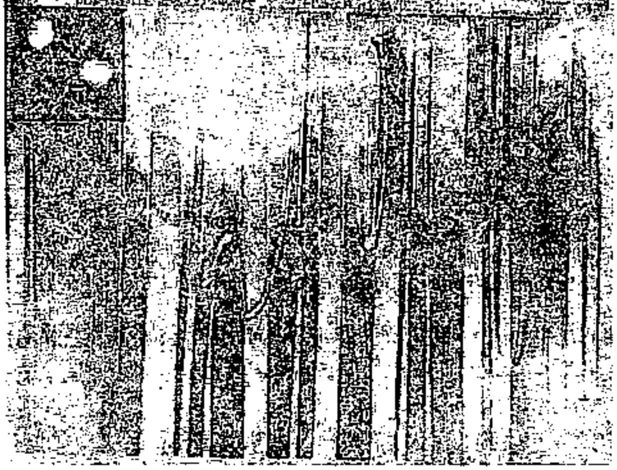

Fig.2

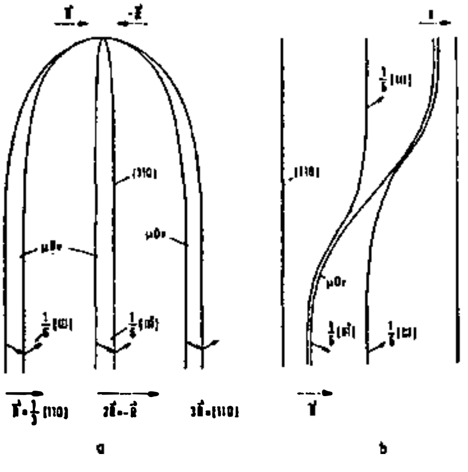

Fig.3