The Stacking Fault Distribution in Copper-Aluminium Martensite and Its Determination

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In a copper-25, 19 at% aluminium martensite a lamellar mixture has been found by transmission electron microscopy. The stacking sequences of the close-packed structures involved are ABCBCACAB and AB.

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I. Introduction

During a study of ternary Cu-Zn-Al-martensitic phases Delaey⁽¹⁾ found that a concentration dependent orthorhombic distortion occurs in the β' -martensite and pointed out that this orthorhombic distortion may be responsible

for the occurrence of a lamellar mixture of two close-packed orthorhombic structures. Such lamellar structures have been observed in different martensitic phases^{(2)~(6)}; the stacking sequences involved are : ABCBCACAB and AB, ABCBCACAB and ABC, and ABCBCACAB and its twinned stacking sequence. This means that, if the

(b)

(c)

(d)

Photo. 1 Electron diffraction pattern of a 25, 19 at% copper-aluminium martensite with the stacking sequence ABCBCACAB and AB

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structure is regarded as a face-centered cubic structure, the total stacking fault density would be larger, smaller or equal than/to $1/3$. The concentration range for the occurrence of those three modes of lamellar mixtures can be calculated from the orthorhombic distortion and the lattice parameters of the α - and β -phases⁽⁷⁾.

During this work the martensitic copper-aluminium alloys have again been studied by transmission electron microscopy in order to prove the existence of such a lamellar mixture in this system.

II. Experimental Procedure

The alloy examined in this work has the composition of 25, 19 at% aluminium. Thin slices (0.1 mm) have been cut from an annealed sample. The slices have been heat treated for 20 min at 900°C in vertical furnace and subsequently quenched in a ten percent NaOH ice-brine solution. The slices have been electrolytically thinned and examined in a Jem 120 electron microscope using a motor-driven large angle goniometer.

III. Results

Photo. 1 (a) shows an electron diffraction pattern which is analysed by Photo. 1 (b), (c) and (d). Photo. 1 (b) is a reproduction of Photo. 1 (a), the circles belonging to one structure and the triangles to an other structure. (Photo. 1 (b) is composed of the diffraction patterns, each one being represented by one of the two following figures Photo. 1 (c) and (d)). It is clear that the diffraction pattern shown by Photo. 1 (c) belongs to a structure with the stacking sequence ABCBCACAB. A detailed examination of this pattern can be found elsewhere, e.g.⁽⁸⁾⁽⁹⁾ The diffraction pattern shown by Photo. 1 (d) belongs to a close packed structure with the stacking sequence AB. From this it is clear that at the considered composition the martensite exists in a lamellar mixture of two close packed structures. The weaker spots, shown by small circles or open triangles, are due to ordering.

In Photo. 2 strong extinction contours are visible together with the frequently mentioned striations. This striations are due to the lamellae⁽¹⁰⁾. The extinction contours come all together in one area, this area gives an electron diffraction pattern with all the spots of planes belonging to the same zone. Such an area has been called "extinction contour configuration"⁽¹⁰⁾. When this area was taken for the selected area diffraction pattern, only the diffraction pattern belonging to the structure with the stacking sequence ABCBCACAB was observed. After carefully tilting and rotating the specimen with a motor-driven large angle goniometer two areas containing extinction contour configurations could be produced (areas labelled A and B in Photo. 3). A careful examination of each of these areas shows that two extinction contour

Photo. 2 Electron micrograph of a copper-aluminium martensite showing an extinction contour configuration ($\times 50000 \times \frac{1}{2}$)

Photo. 3 Electron micrograph of a copper-aluminium martensite showing two "double" extinction contours configuration ($\times 50000 \times \frac{1}{2}$)

configurations can be detected in each area. Selecting one of these areas (e.g. A) Photo. 1 was obtained.

IV. Discussion and Conclusion

This work supports the idea that whenever faulted close packed martensitic phases are ordered, a tendency exists to arrange the faults in thin lamellae, each lamella having an other stacking sequence. One of the stacking sequences is always ABCBCACAB, which is also the easiest found by electron diffraction. Therefore the second kind of lamellae can easily be overlooked, when the foil has not been tilted and rotated step by step in all the directions. This can easily be done by using a motor-driven goniometer.

The stacking sequence in the second kind of lamellae is AB for the concerned alloy composition, which corresponds with the calculations of the total stacking fault density. These calculations have been carried out for the ternary Cu-Zn-Al, Cu-Zn-Ga and Cu-Zn-Si systems⁽⁷⁾. From extrapolations it can be found that the concerned alloy composition falls in the region with the stacking sequences ABCBCACAB and AB.

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