Analysis of High-Density Stacking-Fault Configurations

Many solid-state transformations involve high densities of very wide stacking faults, i.e. the partial dislocations terminating each fault are widely separated. For example, fig. 1 shows a typical configuration of faults in a copper–

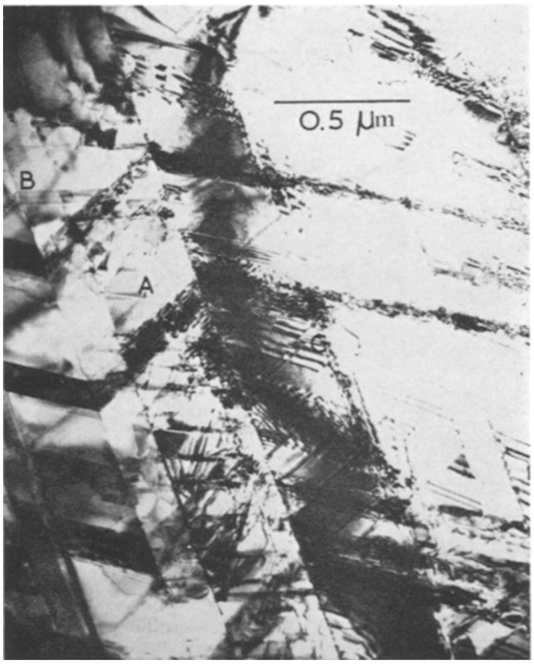

Figure 1a 21 at. % copper-gallium alloy homogenised for 24 h at 850° C, quenched into iced brine, and then annealed for 48 h at 420° C.

gallium alloy of high gallium content, which has been transformed from the bcc β-phase to the cph massive ζ_m-phase, and, subsequently, to the equilibrium α-phase (fcc). Stacking-fault distributions such as that in fig. 1 are conveniently described in terms of "fault vector" space, as follows.

A stacking fault is uniquely described by the Burgers vector of the prismatic dislocation required to create the same fault in a perfect crystal. Further, since the relative orientations of the four $\{1\,1\,1\}$ stacking-fault planes in a fcc crystal are given by the faces of a regular tetrahedron, the corresponding fault vectors constitute a lattice composed of the normals to the faces of a regular tetrahedron: fig. 2a. In the

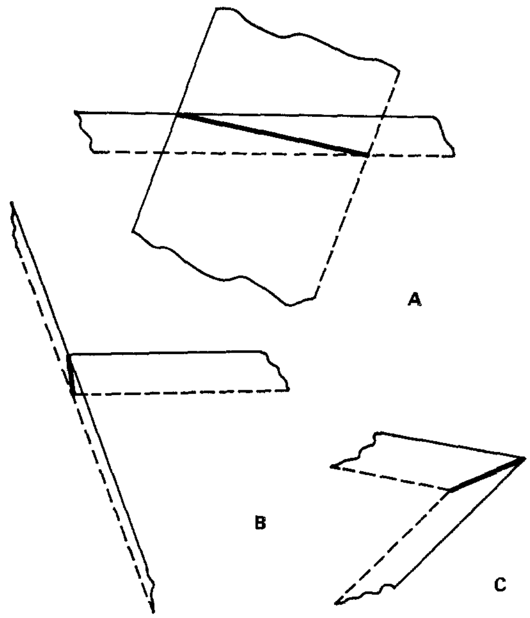

Figure 1b Geometry of the stacking-fault configurations labelled A, B, and C in fig. 1a. Intersections with the foil surfaces are indicated by full and broken lines. Thick lines represent intersections between stacking-fault planes.

case of copper–gallium alloys, the stacking faults are always intrinsic in nature [1], so the following construction will be made for this type of fault. The prismatic dislocation loop in fig. 2b produces an intrinsic stacking fault and, using the FS/RH convention*, an upward-pointing fault vector R is obtained. To assign directions to all four fault vectors, the observer must be able to see all four faults simultaneously, i.e. the observer, O in fig. 2b, must stand outside the tetrahedron. It is evident from fig. 2a that $\Sigma R = O$ at a node in "fault vector" space.

The following properties of the fault-vector lattice permit a complete interpretation of fig. 1.
(a) A continuous lattice of fault vectors, fig. 2c ($\equiv$ diamond lattice), represents a high density of long, *intersecting* stacking faults. Intersecting faults are often observed, e.g. at A in fig. 1, and have been discussed in detail elsewhere [2].
(b) A vector node corresponds to a stacking-fault field (a volume bounded by stacking faults).
(c) A stacking fault separates two fields. Its vector connects the nodes which represent the two fields.
(d) A node having one vector missing represents

*With a Burgers circuit traversed in the direction of rotation of a right-handed screw advancing along the dislocation, the Burgers vector goes from the finish of the circuit to the start.

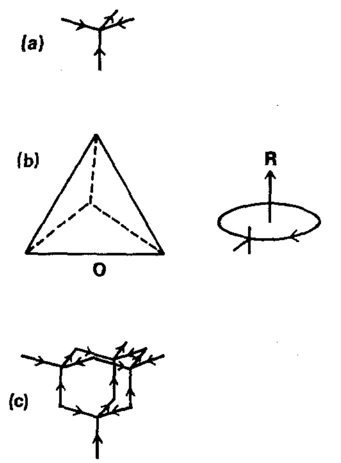

Figure 2 (a) Spatial distribution of fault vectors. (b) Convention for determining the sense of fault vectors. The positive direction of advance along the dislocation is arrowed. (c) Diamond lattice of fault vectors.

a T-junction of two faults, such as that at B in fig. 1. In order to satisfy the $\Sigma \mathrm{R} = \mathrm{O}$ node criterion, one fault must be terminated near the junction by a dislocation, i.e. the faults do not quite touch.

(e) A node with two vectors missing corresponds to a V-junction of stacking faults. To meet the node criterion, a dislocation whose Burgers vector equals the sum of the two missing vectors is required along the "stair-rod". Two V-junctions can be seen at C in fig. 1.

Acknowledgements

This work was stimulated by discussion with Professor F. C. Frank and Dr W. Bollman.

References

1. K. H. G. ASHBEE, L. F. VASSAMILLET, and T. B. MASSALSKI, *Acta Met.* (1966), in press.
2. K. H. G. ASHBEE and L. F. VASSAMILLET, *ibid.*

17 June 1966

K. H. G. ASHBEE
H. H. Wills Physics Laboratory
The University
Bristol, UK

The Structure of Thin Platinum Sheet

It has been shown, by Middleton, Pfeil, and Rhodes [1], that the mechanical properties of platinum prepared by powder-metallurgical methods differ considerably from those of platinum prepared by melting and casting. Betteridge [2], in examining laminated platinum sheet, made a similar observation. In both papers, the difference in properties is attributed either to a dispersion of porosity or to a dispersion of oxides formed from impurities in the platinum.

In the present investigation, material about 12 μm in thickness was prepared by cold rolling at room temperature, with frequent interstage anneals, the final reduction being about 20 to 30%. Three types of platinum were examined: pure cast material, pure sintered material, and sintered material containing about 0.5% of thoria. Thin foils for examination in the electron microscope were prepared by electropolishing in molten NaCl at a temperature just above the melting point of 801° C [3].

In considering the thin-foil microstructure of these specimens, it is important to remember that preparation by electropolishing has itself introduced a heat treatment at 801° C for about 15 to 30 min, producing thermal conditions sufficient to cause complete recovery in pure platinum. The foil prepared from cast material exhibited, indeed, a fully recovered structure, with a subgrain size of about 2 to 3 μm and there was frequent occurrence of narrow markings (twins?) with an average width of about 0.1 μm but varying in width up to 0.2 to 0.3 μm. The foil prepared from sintered material showed a much finer subgrain size (0.5 to 1 μm), and contained spheroidal defects, as shown in fig. 1. The density of defects varied widely in different regions of the foil: that shown in fig. 1 is typical of the average density. No twins were found in that material. The platinum containing 0.5% of thoria still had a fairly high dislocation density, indicating that the presence of thoria particles had retarded recovery.

From these results, it is possible to conclude that the difference in mechanical properties between cast and sintered platinum is due to the presence, in the sintered material, of spheroidal defects. If these defects were oxide particles, it could reasonably be expected that the microstructure of the sintered platinum would more closely resemble that of the platinum containing particles of thoria. It therefore seems most probable that the conclusion of prior workers,