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YIELD SURFACES OF BCC CRYSTALS FOR SLIP ON THE {110} <111> AND {112} <111> SYSTEMS

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The development of deformation textures and the plastic anisotropy of textured materials both depend on the plastic properties of the individual grains that make up the aggregate. These properties are essentially described by the shape of the single crystal yield surface (SCYS). The SCYS for fcc crystals which deform by slip on the {111}<110> systems is well known [1]; by duality, it is identical to the yield surface of bcc crystals slipping on {110}<111>. However, many experimental data [2-4] show that bcc crystals can slip, in the <111> directions, along planes other than {110} ; the one most commonly observed, excluding {110}, is {112}.

The single crystal yield surfaces for slip in bcc metals on either {112}<111> or mixed slip on {110} <111> & {112}<111> have therefore been derived. In particular, for the general case of mixed slip, the SCYS is described in terms of ξ, the ratio of the critical resolved shear stresses for slip on the {110}<111> & {112}<111> systems. All the possible types of yield vertices are tabulated and classified into crystallographically non-equivalent groups. It is confirmed that there is a limited range of ξ for mixed slip :

$$\sqrt{3}/2 < \xi < 2/\sqrt{3}$$

Within this range, there are only 2 different SCYS configurations, depending on whether ξ is greater or smaller than $5/3\sqrt{3}$. Each of these configurations has 15 groups of vertices and 216 stress states (plus their negatives). The two yield surfaces only differ with respect to 3 of the groups of vertices (72 stress states). These latter 72 vertices which activate 3 {110}<111> and 2 {112}<111> systems when $\xi > 5/3\sqrt{3}$, transform into 72 new vertices activating 2 {110}<111> and 3 {112}<111> systems when $\xi < 5/3\sqrt{3}$. Thus when ξ is changed, for a given configuration, only the position of the vertices are modified and not their types or associated slip systems.

For the 15 basic groups of each of the 2 possible configurations of the mixed SCYS, the dependence of the stress vector moduli on the critical resolved shear stress ratio is presented in Fig.1 for the entire range of existence of the mixed polyhedron. At the upper ξ limit ($2/\sqrt{3}$), the A,B,C,D,E notation of Kocks et al. [5] for {110} <111> slip is conserved. At the lower limit ($\sqrt{3}/2$) of ξ, a similar notation based on A',B',C',D',E' is adopted for {112}<111> slip. The particular point at which the 3 groups of vertices converge ($\xi = 5/3\sqrt{3}$) is denoted X. Intermediate groups of mixed slip vertices are denoted by the letters corresponding to the vertex group at the limiting ξ values ($\sqrt{3}/2, 5/3\sqrt{3}, 2/\sqrt{3}$).

The mixed slip stress states activate 5,6,8 slip systems depending on the basic group to which they belong . In the vast majority of cases, only five slip systems are activated so that, by allowing mixed {110}<112> glide, the slip ambiguity problem caracteristic of {110}<111> restricted glide is substantially reduced.

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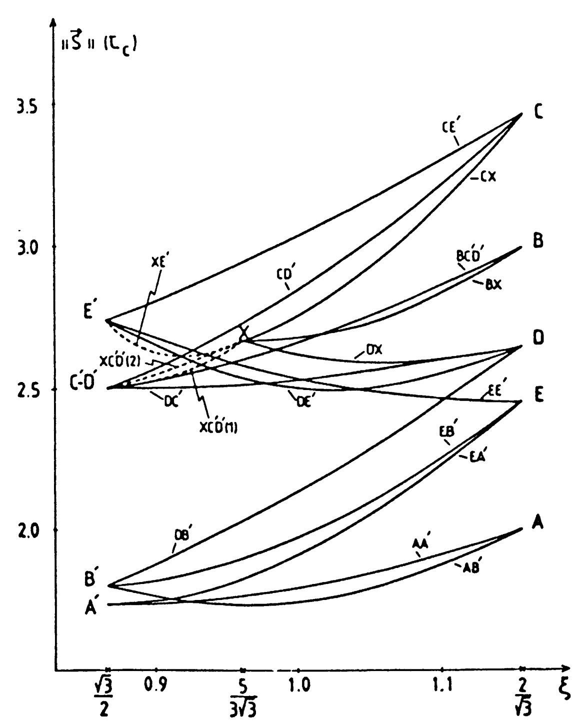

Figure 1 ξ dependence of the yield stress vector moduli.